Salt and Potash Resources in Nova Scotia

by R.C. Boehner

Nova Scotia

Department of
Mines and Energy

a joint project with the
Canada Department of
Regional Economic Expansion

Nova Scotia
Department of
Mines and Energy

Bulletin No. 5

SALT AND POTASH RESOURCES IN NOVA SCOTIA

by

R. C. Boehner

Honourable Joel R. Matheson, Q.C., Minister
John J. Laffin, P. Eng., FEIC, Deputy Minister

Halifax, Nova Scotia
1986

Pugwash Mine
Cumberland County, Nova Scotia
Highly contorted (enterolithic folding) anhydrite at the interbedded contact between major steeply dipping rock salt and anhydrite units.

TABLE OF CONTENTS

Page

ABSTRACT ... 1
ACKNOWLEDGMENTS ... 2
CHAPTER 1. INTRODUCTION ... 3
Historical Background ... 3
Properties, Occurrence and Use of Salt ... 6
General Geology of Nova Scotia ... 7
General Geology of Salt in Nova Scotia ... 7
History of Potash Exploration in Nova Scotia ... 16
Distribution of Salt Deposits and Occurrences ... 19

CHAPTER 2. HANTS-COLCHESTER AREA ... 21
Introduction ... 21
General Windsor Group Stratigraphy ... 21
Beaver Brook Deposit ... 24
Clarksville Occurrence ... 25
Falmouth Occurrence ... 31
Kennetcook Occurrence ... 35
Shubenacadie-Stewiacke Deposit ... 41
Stanley Occurrence ... 47
Summerville Occurrence ... 56
Upper Walton River Occurrence ... 59
Walton Occurrence ... 63
Cheverie ... 66

CHAPTER 3. MAHONE BAY AREA ... 69

CHAPTER 4. CUMBERLAND AREA ... 71
Introduction ... 71
General Geology of the Cumberland Area ... 71
Beckwith Occurrence ... 74
Malagash Deposit ... 75
Nappan Deposit ... 98
Oxford Deposit ... 106
Pugwash Deposit ... 112
Canfield Creek ... 126
Head of Wallace Bay (Simpson Lake) ... 126
Malagash Anticline Between Wallace River and Oxford ... 126
Springhill Area, Black River Diapir ... 128
Roslin Occurrence ... 129

CHAPTER 5. PICTOU AREA ... 139
Introduction ... 139
Dunmaglass-Knoydart ... 139
Kemptown ... 142
Bridgeville ... 142
Salt Springs, Pictou County ... 145

CHAPTER 6. ANTIGONISH-MABOU AREA ... 149
Introduction ... 149
General Geology ... 149
Antigonish Deposit ... 155
James River Deposit ... 158
Mabou Deposit ... 165
Ohio Occurrence ... 175
Pomquet River Occurrence ... 178
Southside Harbour Deposit ... 183

Chapter 7. CANSO-BRAS D'OR AREA ... 193
Introduction ... 193
General Geology and Carboniferous Stratigraphy ... 193
Kingsville Deposit ... 196
McIntyre Lake Deposit ... 197
Malagawatch Deposit ... 211
Orangedale Deposit ... 212
Port Richmond Deposit ... 213
St. Peters Deposit ... 221
Seaview Occurrence ... 225
Recently Discovered Salt Deposits and Areas with Salt Indications in the Canso-Bras d'Or Area ... 227

CHAPTER 8. SYDNEY BASIN AREA 233
Introduction 233
General Geology 233
Boularderie Deposit 233
East Bay Occurrence 239

CHAPTER 9. CHETICAMP-MARGAREE AREA 243
Lake O'Law (Northeast Margaree) Salt Spring 243

CHAPTER 10. CAPE NORTH AREA 245
SELECTED BIBLIOGRAPHY 247

APPENDIX 1. Drillhole Data Summary Tables 267
APPENDIX 2. Chemical Analyses: Salt Rocks and Salt Brines 277
APPENDIX 3. Salt Production in Nova Scotia 309
APPENDIX 4. Index Map of Gravity Survey Coverage in Nova Scotia 313
APPENDIX 5. A Photographic History of Salt and Potash Exploration and Mining in Nova Scotia 317

LIST OF TABLES

Table 1-1. Nova Scotia Department of Mines and Energy salt files and sub files 5

Table 1-2. Nova Scotia salt deposits and occurrences 20

Table 2-1. Chemical analyses, NSDM 4735 (SD-2) 29

Table 2-2. Chemical analyses, evaporated brine, Falmouth occurrence 35

Table 2-3. Chemical analyses, Kennetcook area salt springs 41

Table 2-4. Bromine analyses, Anthony No. 3, Kennetcook occurrence 41

Table 2-5. Summary of salt grades and intervals from drillholes 153-1 and SB-1, Shubenacadie-Stewiacke deposit 53

Table 2-6. Chemical analyses, Otter Brook Spring, Shubenacadie-Stewiacke deposit 54

Table 2-7. Salt spring analyses, Walton area, Hants County 65

Table 2-8. Stratigraphic section, Cheverie area 68

Table 2-9. Chemical analyses of Cheverie brine 68

Table 4-1. Analyses of salt brines, South Wallace and Malagash 98

Table 4-2. Analyses of upper 17 feet of Malagash Mine salt body as sampled by A. O. Hayes in 1918 .... Appendix 2

Table 4-3. Analyses of samples representing channel sampling foot by foot, normal to dip of strata .... Appendix 2

Table 4-4. Composite average of Series A samples .... Appendix 2

Table 4-5. Analyses of salt samples, Amherst No. 1, Nappan deposit 107

Table 4-6. Mineral assemblage by conventional combination, Amherst No. 1 107

Table 4-7. Salt spring analyses, Oxford area, Cumberland County 112

Table 4-8. Chemical analyses, potash sections in Pugwash Mine .... Appendix 2

Table 4-9. Chemical analyses, potash in CRSC-58 and CRSC-59, Pugwash, Nova Scotia .. Appendix 2

Table 4-10. Drill cutting sample analyses, C-96-V, Pugwash area 125

Table 4-11. Chemical analyses of salt springs in the Hartford-Hansford area, Cumberland County 128

Table 4-12. Chemical analyses of Salt Springs, Springhill, Cumberland County 129

Table 4-13. Chemical analyses of Roslin Spring, Cumberland County 133

Table 5-1. Chemical analyses of Kemptown salt spring 142

Table 5-2. Analyses of the salt springs in the Salt Springs area 145

Table 5-3. Analyses of the spring in Salt Springs, Pictou County 145

Table 6-1. Analyses of salt springs, Antigonish deposit 161

Table 6-2. Chemical analyses of salt samples from AP-1-74, James River deposit 166

Table 6-3. Analyses of Glendyer spring, Mabou deposit, Inverness County 175

Table 6-4. Chemical analyses, drill cuttings Port Hood No. 1 176

Table 6-5. Analyses of drill core samples, Port Hood No. 1 and cutting samples from Port Hood No. 1 and Lion Oil Mary No. 1 176

Table 6-6. Analyses of salt springs, Pomquet River area, Antigonish County 184

Table 6-7. Chemical analyses, NSDME 1708, Southside Harbour, Antigonish County 191

Table 6-8. Chemical analyses, Novasel-1 (NSDM 4862), Southside Harbour, Antigonish County 192

Table 7-1. Rock density determinations, NCO Canso Strat No. 1, McIntyre Lake deposit, Inverness County 212

Table 7-2. Chemical analyses, NCO Canso Strat No. 1, McIntyre Lake deposit, Inverness County 213

Table 7-3. Chemical analyses, NCO Canso Strat No. 1, McIntyre Lake deposit, Inverness County 214

Table 7-4. Summary of assay results, Chevron Standard Ltd. drilling at Malagawatch and St. Patricks Channel 217

Table 7-5. Analyses of composite salt samples, drillhole PR-1, Port Richmond deposit .... Appendix 2

Table 7-6. Analyses of composite salt samples (salt core basis) drillhole PR-2, Port Richmond deposit .... Appendix 2

Table 7-7. Analyses of composite salt samples (salt brine basis) drillhole PR-2, Port Richmond deposit .... Appendix 2

Table 7-8. Analyses of composite samples PR-3, calculated on salt core basis, Port Richmond deposit .... Appendix 2

Table 7-9. Analyses of salt core samples, drillhole PM-1, Port Richmond deposit ... Appendix 2

Table 7-10. Analyses of composite samples, calculated on brine basis, from drillhole PR-3, Port Richmond deposit .... Appendix 2

Table 7-11. Chemical analyses, Bucklaw spring, Victoria County 228

Table 7-12. Chemical analyses, drillhole NSDM 478, Bucklaw, Victoria County 229

Table 7-13. Chemical analyses, Whycocomagh spring, Inverness County 230

Table 7-14. Chemical analyses, Baddeck springs, Victoria County 230

Table 7-15. Chemical analyses, Orangedale spring, Inverness County 231

Table 9-1. Chemical analyses, Lake O'Law spring, Inverness County 243

LIST OF FIGURES

Figure 1-1. General geology and location map, Nova Scotia 4

Figure 1-2. Summary of annual salt production in Nova Scotia between 1920 and 1980 6

Figure 1-3. General stratigraphy and tectonic events of Nova Scotia 7

Figure 1-4. Windsor Group outcrop distribution, salt areas and deposits in Nova Scotia .. 8

Figure 1-5. Upper Paleozoic stratigraphy and evaporites in Atlantic Canada 9

Figure 1-6. Lithostratigraphy and major cycles of the Windsor Group in Nova Scotia 10

Figure 1-7. Location map for major cycle sections in Nova Scotia 10

Figure 1-8. Schematic representation of some Windsor Group facies relationships 11

Figure 1-9. Schematic cross-section through the Malagash Anticline illustrating structural complexity of the diapir and settings for potash salts 13

Figure 1-10. New salt and potash resources map .... in pocket

Figure 1-11. Summary of evaporite deposit classification in Nova Scotia 15

Figure 1-12. Distribution of salt deposit structural types in Nova Scotia 15

Figure 1-13. Comparative stratigraphy of selected Windsor Group evaporite basins in Nova Scotia and New Brunswick 18

Figure 2-1. Windsor Group stratigraphy and correlation, Hants-Colchester area 22

Figure 2-2. Structural zonation of the Windsor Group in the Hants-Colchester area 24

Figure 2-3. Geological map and Bouguer gravity anomaly map, Beaver Brook deposit, Colchester County 26-7

Figure 2-4. Drillhole profiles, Beaver Brook deposit, Colchester County 28

Figure 2-5. Bouguer gravity and geological cross-section, Beaver Brook deposit 29

Figure 2-6. Geology in the vicinity of the Clarksville occurrence, Hants County, Nova Scotia 30

Figure 2-7. Drillhole profiles, Clarksville occurrence, Hants County 31

Figure 2-8. Bouguer gravity anomaly map in the vicinity of the Clarksville, Kennetcook, Stanley and Upper Walton River occurrences 32

Figure 2-9. Bouguer gravity and geological cross-section, Clarksville occurrence, Hants County 33

Figure 2-10. Geological map, Falmouth occurrence, Hants County 34

Figure 2-11. Stratigraphic column, western Minas Sub-basin 35

Figure 2-12. Drillhole profiles, Mount Denson, Hants County, Nova Scotia 35

Figure 2-13. Bouguer gravity anomaly map, Falmouth, Summerville and Walton occurrences, Hants County 36

Figure 2-14. Geology in the vicinity of the Kennetcook occurrence, Hants County 38

Figure 2-15. Drillhole profiles, Kennetcook occurrence 39

Figure 2-16. Bouger gravity and geological cross-section, Kennetcook occurrence, Hants County 40

Figure 2-17. Geological map, Shubenacadie-Stewiacke deposit 42

Figure 2-18. Stratigraphic column, Shubenacadie-Stewiacke deposit 44

Figure 2-19. Generalized correlation of drillholes intersecting the Shubenacadie-Stewiacke salt deposit 45

Figure 2-20. Drillhole profiles and correlation, 153-2, 153-1, SB-1, 153-3 and 153-4, Shubenacadie-Stewiacke deposit 48-9

Figure 2-21. Detailed profile of salt sections in drillhole SB-1, Shubenacadie-Stewiacke deposit 50

Figure 2-22. Detailed profile of salt sections in drillhole 153-1, Shubenacadie-Stewiacke deposit 51

Figure 2-23. Structural contour map, Stewiacke Formation salt, Shubenacadie-Stewiacke deposit 52

Figure 2-24. Bouguer gravity anomaly map, Shubenacadie-Stewiacke deposit 52

Figure 2-25. Schematic geological and Bouguer gravity cross-sections, Shubenacadie-Stewiacke deposit, Hants and Colchester Counties 53

Figure 2-26. Geology in the vicinity of the Stanley occurrence, Hants County 55

Figure 2-27. Drillhole profiles, Stanley occurrence 56

Figure 2-28. Bouguer gravity anomaly map and cross-section, Stanley occurrence 57

Figure 2-29. Geological map of the Summerville occurrence, Hants County 58

Figure 2-30. Drillhole profiles, Summerville occurrence, Hants County 59

Figure 2-31. Geology in the vicinity of the Upper Walton River occurrence, Hants County .. 60

Figure 2-32. Drillhole profiles, Upper Walton River occurrence 61

Figure 2-33. Multiple structural repetition of a single carbonate unit in drillhole GM-5, Upper Walton River occurrence 62

Figure 2-34. Schematic interpretation of multiple repetition in GM-5, Upper Walton River occurrence 63

Figure 2-35. Geology in the vicinity of the Walton occurrence, Hants County 64

Figure 2-36. Geology of the Cheverie area, Hants County, Nova Scotia 66

Figure 2-37. Drillhole profile, Cheverie No. 1, near Cheverie 67

Figure 3-1. Geology of the Mahone Bay area 69

Figure 4-1. Bouguer gravity anomaly map and salt diapirs, Cumberland area 73

Figure 4-2. Geology in the vicinity of the Beckwith occurrence, Cumberland County, Nova Scotia 76-7

Figure 4-3. Drillhole profiles, Beckwith occurrence, with legend for Cumberland drillhole profiles 78

Figure 4-4. Bouguer gravity and geological map with accompanying cross-section, Beckwith occurrence 79

Figure 4-5. Geology compilation map, Wallace-Malagash area, Cumberland County 80

Figure 4-6. Structure contour map on the base of the Lucas seam with accompanying sections, Malagash Mine 81

Figure 4-7. Bouguer gravity and geological cross-sections, Malagash deposit 85

Figure 4-8. Bouguer gravity anomaly map, Wallace-Malagash area, Cumberland County 86

Figure 4-9. Total intensity magnetometer survey, Wallace-Malagash area 87

Figure 4-10. Drillhole profiles Malagash Nos. 1 and 2, Malagash deposit 88

Figure 4-11. Drillhole profiles, Wallace Nos. 1 and 2, Malagash deposit 90-1

Figure 4-12. Geological map and cross-section, Lazy Bay 92

Figure 4-13. Drillhole profiles, Anschutz, Wallace Station No. 1 and Pacific Fox Harbour C-96-V, Cumberland County 93

Figure 4-14. Malagash Mine plan, Lucas seam, west workings 94

Figure 4-15. Malagash Mine plan, Lucas seam, east workings 95

Figure 4-16. Drillhole location map, Malagash Mine 96

Figure 4-17. Reflection seismic survey showing structural contours on a Windsor Group horizon, Malagash-Wallace area 97

Figure 4-18. Geology in the vicinity of the Nappan deposit, Minudie Anticline 100-1

Figure 4-19. Lime-kiln Brood area, geological map and cross-section 102

Figure 4-20. Drillhole profiles, Nappan deposit, Cumberland County 104

Figure 4-21. Bouguer gravity and geological profile, Nappan deposit 105

Figure 4-22. Drillhole profile, Gulf et al., Hastings No. 1, Cumberland County 106

Figure 4-23. Bouguer gravity anomaly map, Nappan deposit 107

Figure 4-24. Bromine content of halite in Sunoco No. 1A, Nappan deposit 108

Figure 4-25. Geology in the vicinity of the Oxford deposit 109

Figure 4-26. Drillhole profiles, Oxford deposit 111

Figure 4-27. Bouguer gravity and geological cross-section, Oxford deposit 112

Figure 4-28. Bouguer gravity anomaly map, Oxford deposit 113

Figure 4-29. Geology in the vicinity of the Pugwash deposit, Canfield Creek and Simpson Lake, Cumberland County 114

Figure 4-30. Simplified stratigraphy of the sequence exposed in the Pugwash mine 115

Figure 4-31. Stratigraphic column of the lower part of the section exposed in the Pugwash Mine 116

Figure 4-32. Simplified geological map and mine plan, 630 foot level, Pugwash Mine, Cumberland County 118

Figure 4-33. Geological cross-sections A-A_1, and B-B_1 Pugwash Mine 119

Figure 4-34. Drillhole profiles, Pugwash deposit, Cumberland County 120

Figure 4-35. Update mine plan, 630 foot level, Pugwash Mine 121

Figure 4-36. Mine plan, 830 foot level, Pugwash Mine 122

Figure 4-37. Bouguer gravity anomaly map, Pugwash deposit 123

Figure 4-38. Geological, geochemical and geophysical profiles, CRSC #58 and #59, Pugwash deposit 124

Figure 4-39. Horizontal bromine profiles of stratigraphic units in drill core and mine workings, Pugwash Mine 125

Figure 4-40. Stratigraphic bromine profile of salt units exposed in the Pugwash Mine 126

Figure 4-41. Bouguer gravity anomaly map, Canfield Creek, Cumberland County 127

Figure 4-42. Geology in the vicinity of Canfield Creek, Cumberland County 128

Figure 4-43. Geology in the vicinity of Hartford, Cumberland County 128

Figure 4-44. Geology in the vicinity of Black River near Springhill, Cumberland County 130

Figure 4-45. Geological cross-section and legend to accompany Black River area geology map, Figure 4-44, Cumberland County 131

Figure 4-46. Geology in the vicinity of the Roslin occurrence, Cumberland County 133

Figure 4-47. Drillhole profile, Roslin No. 1 (NSDM 4307), Roslin occurrence, Cumberland County 134

Figure 4-48. Geological map and Bouguer gravity anomaly map with accompanying cross-section, Roslin occurrence, Cumberland County 135

Figure 4-49. Magnetometer survey, Roslin area, Cumberland County 136

Figure 4-50. Preliminary seismic survey shot points location map, Roslin occurrence, Cumberland County 137

Figure 5-1. Geological map, Dunmaglass, Antigonish County 140-1

Figure 5-2. Correlation of Windsor Group strata in hole HB Fina F-25, with the Windsor Group of the Shubenacadie Basin 143

Figure 5-3. Geological map, Kemptown area, Colchester County 144

Figure 5-4. Geological map, Bridgeville area, Pictou County 146-7

Figure 6-1. Geological map of the Antigonish Basin showing salt deposits geological map areas 150

Figure 6-2. Horton Group stratigraphy and general correlation, Antigonish-Mabou area, Nova Scotia 151

Figure 6-3. Summary of Antigonish Basin stratigraphic nomenclature with approximate age correlation 152

Figure 6-4. Stratigraphic column for Antigonish Basin 153

Figure 6-5. Preliminary Windsor Group stratigraphic columns, Antigonish-Mabou area 154

Figure 6-6. Geological map and legend, Antigonish deposit 156-7

Figure 6-7. Drillhole profiles, Antigonish deposit 159

Figure 6-8. Bouguer gravity and geological cross-section, Antigonish deposit 160

Figure 6-9. Gravity anomaly and general geological map, Antigonish deposit 160

Figure 6-10. Geological map, James River deposit, Antigonish County 162

Figure 6-11. Drillhole profiles, James River deposit 164

Figure 6-12. Bouguer gravity and geological profiles, James River deposit 165

Figure 6-13. Bouguer gravity and general geological map, James River deposit 165

Figure 6-14. Geology in the vicinity of the Mabou deposit, Inverness County 168-9

Figure 6-15. Drillhole profiles, Mabou deposit 170

Figure 6-16. Gravity and geological cross-section, Mabou area, Inverness County 171

Figure 6-17. Schematic cross-section of the Mabou deposit 173

Figure 6-18. Bouguer gravity and general geology, Mabou area, Inverness County 174

Figure 6-19. Geological map, Ohio occurrence, Antigonish County 177

Figure 6-20. Drillhole profiles, Ohio occurrence, Antigonish County 179

Figure 6-21. Geological cross-section, Ohio occurrence 180

Figure 6-22. Geological map, Pomquet River occurrence, Antigonish County 181

Figure 6-23. Drillhole profiles, Pomquet River occurrence, Antigonish County 182

Figure 6-24. Bouguer gravity anomaly and general geological map, Pomquet River occurrence, Antigonish County 182

Figure 6-25. Reflection seismic survey, Line 6, Pomquet River occurrence, Antigonish County 183

Figure 6-26. Geology in the vicinity of the Southside Harbour deposit, Antigonish County 185

Figure 6-27. Drillhole profiles, Southside Harbour deposit, Antigonish County 186

Figure 6-28. Geological and gravity cross-section, Southside Harbour deposit, Antigonish County 188

Figure 6-29. Residual gravity anomaly map, Southside Harbour deposit, Antigonish County 189

Figure 6-30. Reflection seismic survey, Lines 7 and 8, Southside Harbour deposit, Antigonish County 190

Figure 6-31. Bromine profile, NSDM 1708, Southside Harbour deposit 191

Figure 7-1. Composite Bouguer gravity anomaly map, Canso-Bras d'Or area, Cape Breton Island 194

Figure 7-2. Geology in the vicinity of the Kingsville deposit, Inverness County 196-9

Figure 7-3. Drillhole profiles, Kingsville deposit, Inverness County 200-2

Figure 7-4. Geological and gravity cross-section, Kingsville deposit, Inverness County .. 203

Figure 7-5. Bouguer gravity anomaly map, Kingsville deposit, Inverness County 203

Figure 7-6. Geology in the vicinity of the McIntyre Lake and Port Richmond deposits, Inverness and Richmond Counties 204-5

Figure 7-7. Drillhole profile NCO Canso Strat No. 1, McIntyre Lake deposit, Richmond County 207

Figure 7-8. Drillhole profile NCO Canso Strat No. 2, McIntyre Lake deposit, Richmond County 208

Figure 7-9. Geological and Bouguer gravity cross-section, McIntyre Lake deposit, Inverness County 209

Figure 7-10. Stratigraphic and structural section C-C_1 showing distribution of Lower (screened) and Upper Windsor strata, and potash occurrences (black dots) 210

Figure 7-11. Bouguer gravity anomaly map, McIntyre Lake and Port Richmond deposits 211

Figure 7-12. Geology in the vicinity of the Malagawatch, Estmere and Orangedale deposits, Inverness County 214-5

Figure 7-13. Schematic summary of total depth and stratigraphic section penetrated in Chevron Standard Ltd. drilling at Malagawatch and St. Patricks Channel 216

Figure 7-14. Bouguer gravity anomaly map, Orangedale deposit, Inverness County 218

Figure 7-15. Drillhole profiles DCPR-4 to -10, Port Richmond deposit, Richmond County 219

Figure 7-16. Drillhole profiles DCPR-1 to -3, PM-1 and CIL-1, Port Richmond deposit 220

Figure 7-17. Geological and Bouguer gravity cross-section, Port Richmond deposit, Richmond County 221

Figure 7-18. Geology in the vicinity of the St. Peters deposit and Seaview occurrence, Richmond County 222-3

Figure 7-19. Drillhole profiles, St. Peters Nos. 1 and 3 (2) and Seaview No. 2, St. Peters deposit and Seaview occurrence, Richmond County 224

Figure 7-20. Geological and Bouguer gravity cross-section, St. Peters deposit 224

Figure 7-21. Bouguer anomaly map, St. Peters-Seaview area, Richmond County 225

Figure 7-22. Residual gravity anomaly map, St. Peters-Seaview area, Richmond County 226

Figure 7-23. Geological and Bouguer gravity cross-section, Seaview occurrence 227

Figure 8-1. Geology in the vicinity of the East Bay occurrence, Cape Breton County 234-5

Figure 8-2. Correlation and stratigraphy of limestone units in the Sydney area, Cape Breton County 236

Figure 8-3. Geology in the vicinity of the Boularderie deposit, Victoria County 237

Figure 8-4. Drillhole profile NSDME Kempt Head 84-1, Boularderie deposit, Victoria County 238

Figure 8-5. Drillhole profiles, East Bay occurrence, Cape Breton County 240

Figure 8-6. Geological cross-section, East Bay occurrence, Cape Breton County 241

Figure 9-1. Gravity anomaly map, Margaree area, Cape Breton Island 243

Figure 9-2. Geology in the vicinity of the Lake O'Law salt spring 244

SALT AND POTASH RESOURCES IN NOVA SCOTIA

by

R. C. Boehner

ABSTRACT

The salt and potash resources of Nova Scotia are described from all available geological, geophysical and geochemical data. Twenty-three deposits and thirteen occurrences are known with subeconomic potash (sylvite and carnallite) associated with thirteen of the salt deposits in the Middle to Late Viséan (Early Carboniferous) Windsor Group. Minor evaporites, including halite, are locally present in the underlying Horton Group but no potentially exploitable deposits are known.

The Windsor Group (Viséan) is a regionally widespread unit up to 1000 metres thick. It is dominated by subaqueous and diagenetic marine evaporites, including halite, anhydrite, gypsum and potash, with subordinate interstratified redbeds and marine carbonates. These rocks display a wide range of structural and stratigraphic complexities within the Carboniferous depositional and tectonic setting. Carboniferous basins in Nova Scotia are part of the complex Magdalen (Fundy) Basin system developed in the Acadian Orogen in Atlantic Canada. They contain up to 7000 metres of pull-apart basin molassic sediments with minor, but economically important, marine evaporites of the Windsor Group. Deformation varies from negligible in the relatively stable platform blocks characterized by thin sediment accumulation, to substantial deformation in the fragmented basinal areas involving Hercynian strike slip, thrust and normal faulting, gravity sliding, evaporite diapirism and folding of the thick sedimentary fill.

Until recently, the distribution and geology of the evaporites, especially salt and potash, have been poorly understood because of limited data. Recent drilling has established that salt is present throughout the Windsor Group section. The principal salt unit including potash (sylvite and carnallite) is located in a major carbonate-sulphate-chloride cycle at the base of the Windsor Group. Thinner and younger salt beds with minor potash are locally present in association with anhydrite and marine carbonate in numerous saline minicycles.

The major salt producers in Nova Scotia are a conventional underground mine at Pugwash operated by The Canadian Salt Company Limited and a brining mine at Nappan operated by Domtar Incorporated, Sifto Salt Division. Nova Scotia has large salt resources and some potash. It is located near potential markets and along major shipping routes. These factors should enhance further development of mining, chemical and underground storage industries in the Province.

ACKNOWLEDGMENTS

The writer is indebted to each and all previous workers who have contributed to the present knowledge of salt geology through published and unpublished reports and maps of the Carboniferous basins in Nova Scotia.

The writer also acknowledges R. Jones, L. Miller, S. Parsons, K. Crowell, J. Fahie and B. MacDonald who patiently typed the manuscript; D. Bernasconi, G. Macdonald, P. Belliveau, W. Burt, J. DeWolfe and J. Campbell for drafting; R. Morrison and C. MacKinnon for photography; and S. Harnish for diligent library rearch and file duplication. The manuscript was technically edited by K. Mills and J. Bates, and critically read by Dr. R. D. Howie.

CHAPTER 1
INTRODUCTION

Nova Scotia is located in Southeastern Canada and borders on the major shipping routes of the Atlantic Ocean (Fig. 1-1). The Province has many seaports including two excellent ice-free deep water ports, Halifax and the Strait of Canso.

Although metallic minerals including gold, copper, lead and zinc have been mined to some extent, the nonmetallic and industrial mineral industry has made a far more significant contribution to the economy of the Province. This industry is based largely on the mining of gypsum, salt and limestone deposits found primarily in rocks belonging to the Lower Carboniferous Windsor Group and coal from Upper Carboniferous strata. Barite and celestite are also important minerals produced from the Windsor Group. At present, salt production is confined to the underground mine at Pugwash operated by the Canadian Salt Company Limited and the brining mine operated by Domtar Chemicals Limited (Sifto Salt Division) at Nappan, Cumberland County. Nova Scotia's large salt deposits gave it an important mineral resource base for the development of new mines, chemical industries, and underground storage structures.

The study presented in this report was undertaken to update the locations, limits, and structural configurations of Nova Scotia's deposits by reviewing available data. The major source of these data are the mineral assessment files of the Nova Scotia Department of Mines and Energy that contain, for the most part, unpublished reports submitted by exploration companies. Less abundant, but very important data are also available in a few published papers on salt geology in Nova Scotia.

Salt deposits are located and defined by the direct methods of exploratory drilling and/or the locating of salt springs, and indirectly by gravity surveys. The Nova Scotia Research Foundation Corporation has been instrumental in a systematic regional gravity survey of potential salt areas throughout Nova Scotia. An index map of available gravity coverage is presented in Appendix 4.

The following study has been organized by region, area, deposit or occurrence. The files used to prepare this compilation are available at the Nova Scotia Department of Mines and Energy, Halifax. The method of documentation is shown on Table 1-1.

The well documented stratigraphic and structural complications associated with Nova Scotia's salt structures, together with the lack of sufficient surface and subsurface data, make accurate detailed interpretations of many deposits and occurrences extremely difficult. Exceptions are the detailed work by Evans (1972) on the complexly deformed Pugwash Mine geology and the relatively undisturbed Shubenacadie-Stewiacke deposit described by Boehner (1980a).

The writer examined diamond-drill cores containing salt in the Shubenacadie-Stewiacke area and the Antigonish area. All other drillhole logs have been extracted from exploration companies geologists' logs and reports in assessment files. This report is part of the Mineral Resource Inventory Program. It outlines the available geological data on the salt resources in the Province and constitutes a data base from which more detailed work can be extended. Subsequent reports on individual deposits and occurrences will be prepared as the data become available.

HISTORICAL BACKGROUND

Major contributions to understanding the stratigraphy, paleontology and structure of the Carboniferous succession, in particular the Windsor Group in Nova Scotia and Atlantic Canada, were made by W. A. Bell and other geologists with the Geological Survey of Canada. These studies have formed the basis of the understanding of Carboniferous strata. Early workers who have made major contributions to the field of salt geology in Nova Scotia include: Bell (1944, 1958), Sage (1954), Stacey (1953), Hayes (1920, 1931), Chambers (1924), Cole (1926, 1930a,b), Ellsworth (1926), Norman (1932b, 1935) and Bancroft (1938). More recent work includes: Evans (1970a,b,c, 1972), Howie (1979), Goudge (1967), Goodman (1952), Shea (1970), Bidgood (1970), and Bidgood and Blanchard (1967).

An early reference to salt and salt springs in Nova Scotia was made by Haliburton (1829) in historical accounts of several areas including West River of Pictou (1829, p. 58), River Philip (1829, p. 37), Black River near Springhill (1829, p. 68 and 434) and the upper end of the Stewiacke Valley (1829, p. 36 and 37). Detailed descriptions and locations, however, were not reported.

Another early reference to salt and salt springs in Nova Scotia was made by Gesner (1849, p. 264-265) in a general outline of the industrial resources of the Province. Gesner referred mainly to the abundance of springs in Hants County and parts of Colchester County. No specific statements with regard to locations and brine composition were made.

Dawson (1868, p. 276 and 349) reported that brine springs occurred in several parts of Nova Scotia including Walton and Antigonish. Detailed descriptions of their location and composition were not mentioned.

The earliest recorded attempt to mine salt in Nova Scotia occurred in 1813 near Salt Springs, Pictou County. Cole (1930b, p. 7) reported a 60 m shaft had been sunk to locate the source of salt brine found in small springs and seeps in the vicinity. The venture was unsuccessful, although a few years later a small amount of salt was apparently produced by evaporating the brine.

Salt was reported by How (1869) to have been made from the "Salt Pond" near Antigonish prior to 1866. In 1866, according to How (1869), Dawson (1868) and Fletcher (1887), salt ventures were undertaken at Town Point and in Antigonish

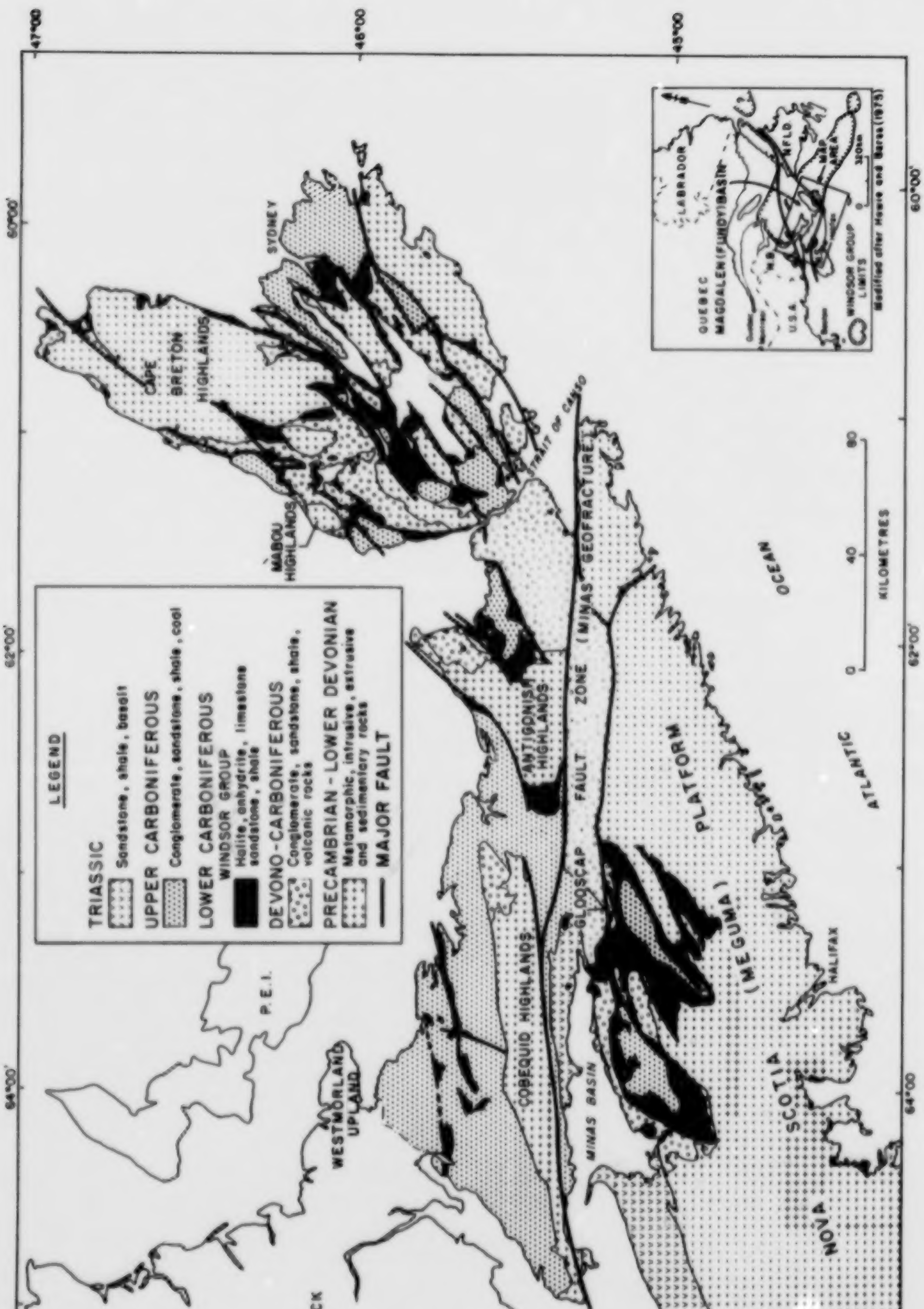

47°00'
46°00'
45°00'
64°00'
62°00'
60°00'
LEGEND
TRIASSIC
Sandstone, shale, basalt
UPPER CARBONIFEROUS
Conglomerate, sandstone, shale, coal
LOWER CARBONIFEROUS
WINDSOR GROUP
Halite, anhydrite, limestone sandstone, shale
DEVONO-CARBONIFEROUS
Conglomerate, sandstone, shale, volcanic rocks
PRECAMBRIAN-LOWER DEVONIAN
Metamorphic, intrusive, extrusive and sedimentary rocks
MAJOR FAULT
NEW BRUNSWICK
WESTMORLAND UPLAND
P.E.I.
BAY OF FUNDY
MINAS BASIN
COBEQUID HIGHLANDS
GLOOSCAP
FAULT
ZONE
(MINAS GEOFRACTURE)
ANTIGONISH HIGHLANDS
MABOU HIGHLANDS
STRAIT OF CANSO
CAPE BRETON HIGHLANDS
SYDNEY
PLATFORM
(MEGUMA)
NOVA SCOTIA
HALIFAX
ATLANTIC
OCEAN
0
40
80
KILOMETRES
QUEBEC
LABRADOR
MAGDALEN (FUNDY) BASIN
U.S.A.
N.B.
NFLD
MAP AREA
WINDSOR GROUP LIMITS
320km
Modified after Howie and Barss (1975)

Figure 1-1. General geology and location map, Nova Scotia.

Table 1-1. Nova Scotia Department of Mines and Energy salt files and sub files (sub files colour coded).

SUB FILE 1: Historical Background

NTS Code, Occurrence Name

SUB FILE 2: Geography and Physiography

1:50 000 topography map showing location
Summary of existing reports

SUB FILE 3: Geological Data

Copies of geological maps, reports
Location map for drillholes
Copies of all descriptive drill logs
Copies of all graphic drill logs
Mineralogy of the occurrence/deposit
Geometry of the deposit, suggested structural configurations, cross-sections, etc.
Stratigraphic position of the deposit

SUB FILE 4: Geophysical Data

Copies of gravity surveys, regional and local
Gravity cross-sections
Reports of gravity interpretation
Copies of all available magnetometer surveys
Down-hole geophysics - copies of all logs

SUB FILE 5: Geochemical Data

Types of analyses: brine, whole-rock, salt springs, etc.
Standard format, list of elements, oxides, etc.
Retabulation of all available data

SUB FILE 6: Economic Considerations

(Table form)
Economic minerals present
Approximate depth
Approximate dimensions
Average grade
Proven reserves
Possible reserves
Current utilization
Comments

SUB FILE 7: Source Documents

Bibliography including NSDME assessment file numbers.

SUB FILE 8: Assessment of File Quality

Data type (quantitative, qualitative, geological, geophysical, geochemical).
Insufficient-sufficient
Questionable-reliable
Data update
Utilization planning

by Josiah Deacon, manager at the Nova Scotia Salt Works and Exploration Company. Brine suitable for salt production was encountered in the Antigonish borings, but the quantity and quality of the brine decreased and subsequent boring was unsuccessful in reaching suitable brine. The operation was abandoned and no further developments were reported.

Salt was also reported by How (1869, p. 144) to have been manufactured at Springhill, Cumberland County, in 1867. Details about the operation are sketchy, however, it is assumed to have been abandoned with little significant production.

In the Malagash area in 1912, Peter Murray obtained a flow of salt water in a water well borehole at a depth of approximately 25 m. The salt water obtained was analyzed by Cole (1930b) who reported a nearly saturated salt (NaCl) brine. This incident, together with the presence of salt springs in the vicinity, prompted further drill exploration by Chambers and McKay of New Glasgow in 1917. Twelve boreholes were sunk and brine was encountered in six, at depths ranging from 26 to 34 m. Based upon this success, a diamond-drill hole was put down and intersected salt between depths of 29 and 53 m. A shaft was subsequently sunk nearby, reaching salt at a depth of 26 m. The Malagash Salt Mine was developed in this deposit and was an active producing mine between 1920 and 1959.

A report on the potash possibilities of Nova Scotia sponsored by Imperial Chemical Industries Limited of New York, was published by Hayes (1931). This comprehensive report on the saline rocks and springs in Nova Scotia forms an excellent compilation of available data.

In drilling for petroleum in 1931, the Imperial Oil Company (Amherst No. 1) penetrated a thick deposit of salt at Nappan near Amherst, Cumberland County. Between 1942 and 1944 the Nova Scotia Department of Mines carried out a drilling program to define the salt deposit at Nappan Station near the Amherst No. 1 drillhole. Between 1945 and 1947, Sun Oil Company Limited drilled Sunoco Nos. 1 and 1A and also intersected a thick salt zone in the same area. In 1946 Maritime Industries Limited drilled brine production wells into the salt deposit at Nappan and a brining plant was installed. The mine is presently operated by the Sifto Salt Company (Domtar).

In 1952-53 the Nova Scotia Department of Mines drilled several holes in the Southside Harbour area near Antigonish exploring for salt. The program was sponsored by the Nova Scotia Department of Trade and Industry to evaluate the potential development of a soda ash industry. A large mass of salt was intersected, but the project was terminated. Further drilling in the vicinity was undertaken in 1969 by Novasel Ltd. A single diamond-drill hole was sunk in which a thick section of salt was intersected, but again the project was abandoned because of unfavourable economic conditions.

In the later years of the operation of the Malagash Salt Mine, difficulties with haulage, ore grade and cracked mine support pillars forced the Malagash Salt Company to explore for another salt deposit. Exploration drilling was undertaken in Cumberland and Antigonish Counties and resulted in the discovery of the Pugwash salt deposit near Pugwash Harbour. By 1959, production began at the Pugwash deposit, and the Malagash Mine was phased out and abandoned. The Pugwash Mine is presently operated by the Canadian Salt Company Ltd. A summary of annual salt production in Nova Scotia is presented in Figure 1-2.

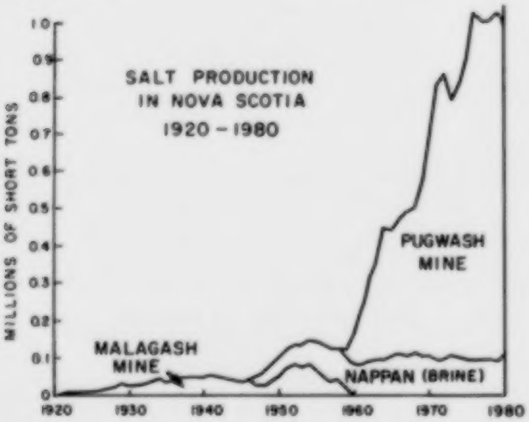


Figure 1-2. Summary of annual salt production in Nova Scotia between 1920 and 1980.

In 1966 the Atlantic Development Board sponsored a potash exploration program in Cumberland County, Nova Scotia. Specific targets were the potash zones found in the Malagash Salt Mine to the deeper parts of the Malagash Anticline towards the west. Four holes were drilled in the Malagash-Wallace area and of these, two intersected potash mineralization at depth. Excessive depths, low grades, and thin mineralized zones have discouraged additional drilling.

The Strait of Canso area has been explored both for potential underground petroleum storage and for a salt brining mine. Dow Chemical Company has developed an underground storage cavern at Port Richmond, 10 km east of Port Hawkesbury. Home Oil Canada Limited et al. has explored the McIntyre Lake area, 6.5 km northeast of Port Hawkesbury, for potential development of underground storage facilities. Domtar has planned the possible development of a brining mine at Kingsville, 20 km north of Port Hawkesbury. Each of these projects is presently in a state of deferment pending improvement in the economic aspects of the respective ventures.

PROPERTIES, OCCURRENCE AND USE OF SALT

Halite, the mineralogical name for salt, is a chloride of sodium with the chemical formula NaCl (Na 39.34 weight per cent, Cl 60.66 weight per cent). Halite is an isometric mineral most commonly occurring in nature as rock salt, a granular crystalline mass comprised mostly of the mineral halite (Hurlbut, 1971). Because of its simple structure, halite was the first mineral to be analyzed by X-rays. Pure halite is transparent to translucent and is colourless to white, but when impure it may have shades of red, yellow, grey or blue. It typically displays a perfect cubic cleavage, has a Mohs hardness of 2 (scratched by a finger nail), and a specific gravity of 2.168 (pure NaCl) placing it among the lightest of the naturally occurring rock forming minerals. Halite is very soluble in water: 35.7 parts per 100 parts water at 0°C, and 39.8 parts per 100 parts water at 100°C (Lefond and Jacoby, 1975).

Halite is a common mineral occurring in a variety of geological circumstances. Halite occurs in rocks that range in age from Precambrian to Recent throughout the world. Halite is the most abundant dissolved constituent of seawater, estimated at 18.76 million km^3 (Lefond and Jacoby, 1975).

Rock salt occurs as very thick deposits in the Windsor Group (Early Carboniferous) of Atlantic Canada, both on land and in the offshore areas. These salt deposits are part of an extensive marine evaporite succession with associated anhydrite ($CaSO_4$) and locally with the potash salts sylvite and carnallite (KCl and $KCl.MgCl_2.6H_2O$), located notably in the Sussex and Salt Springs areas of New Brunswick. The salt deposits of Atlantic Canada were originally bedded deposits, precipitated from seawater in a series of restricted basins which formed in the Fundy Basin (Bell, 1929, 1958) or the Fundy Aulacogene (Keppie, 1977) during Early Carboniferous time. The halite is interstratified with anhydrite and gypsum, marine limestone and dolostone and red-green terrigenous clastics. Most have since been modified during tectonism into pillows, anticlines and diapirs-domes with variable structural complexities.

Salt or halite has had a long history of domestic and industrial use. Its earliest uses were related to food preparation and preservation, although a much broader utility exists at present. A large portion (39.1% in 1976 and 23.6% in 1979) of salt consumed in Canada was used in chemical industries (Boyd, 1977). Products include chlorine, caustic soda, hydrochloric acid, sodium metal, and over 30 other basic chemicals. These basic chemicals in turn were used in the manufacture of about 14 000 additional chemicals.

In northern climates salt is used for snow and ice control on highways. This use comprised 52.5% of the total salt consumed in Canada in 1976 and 67.7% in 1979.

Food processing and related industries including fishing, meat packing, tanning and agriculture consume the major share of the remainder (7% in 1976 and 8.7% in 1979). Slightly over 1% is used in the pulp and paper and textile industries (Boyd, 1977).

Salt production in Canada has ranged from 6.257 million t in 1976 (Boyd, 1976) to 6.918 million t in 1979 (Barry, 1979). The share produced in Nova Scotia during the same period has increased from 15% to 16.6%.

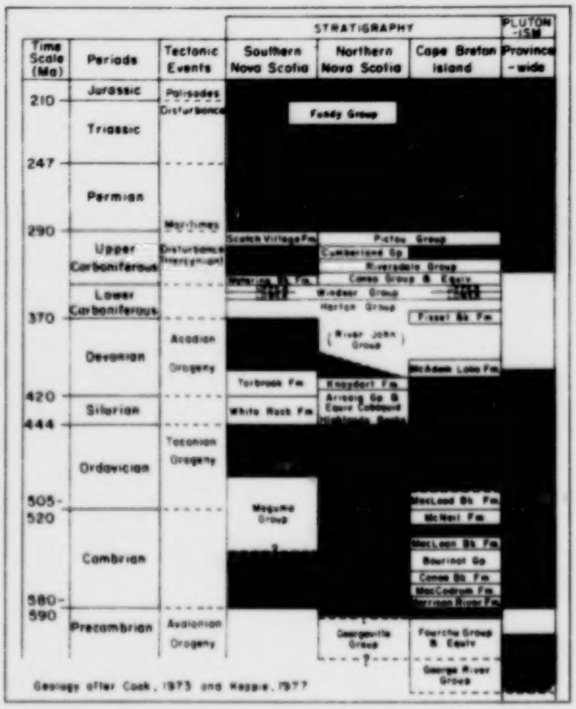
Salt deposits are becoming increasingly important as a host rock in the development of pressurized and unpressurized underground storage structures (Martinez and Thoms, 1977). Constant temperature and humidity, together with its impermeablity, solubility and plastic behaviour, make salt an important resource in developing storage structures. Worked out salt mines and brined deposits can be used for liquid or dry storage of materials such as petroleum products, compressed air and industrial wastes. Deposits presently unsuitable for conventional mining methods may be suitable for creating artificial caverns through solution mining. Petroleum and its liquid and gas derivatives may be stored as strategic reserves or as part of a refinery trans-shipment complex. The Strait of Canso area on Cape Breton Island, with its excellent deep water docking facilities, proximity to frontier petroleum areas, potential market areas, and nearby salt deposits, appears to be ideally situated for such underground storage structures. The process, however, results in the loss of the salt as a future mineral reserve for mining operations, and its use should be carefully assessed.

GENERAL GEOLOGY OF NOVA SCOTIA

Nova Scotia may be broadly divided into three major geological areas (Figs. 1-1 and 1-3): southern Nova Scotia, northern Nova Scotia and Cape Breton Island. The Glooscap Fault System (Minas Geofracture of Keppie, 1982a), which trends westerly from Chedabucto Bay to the Bay of Fundy, separates southern Nova Scotia from northern Nova Scotia and Cape Breton Island. A summary of the major stratigraphic and tectonic events affecting these areas is presented in Figure 1-3.

The Precambrian to Early Devonian rocks are generally penetratively deformed by one or more of three principal tectonic events: the Precambrian Avalonian Orogeny, the Ordovician Taconian Orogeny and the Devonian Acadian Orogeny. The major orogenies have been attributed to the collision of various plates (Keppie, 1977, 1982a,b). The area to the south of the Minas Geofracture (Keppie, 1982a) is composed of Lower to Middle Paleozoic rocks of the Meguma Group. These rocks were folded during the Devonian Acadian Orogeny into northeasterly to easterly trending upright folds. According to Keppie (1977), basic dykes and sills were emplaced during the Silurian prior to the deformation. Granites intruded the folded and deformed rocks during Devonian and Early Carboniferous time. Throughout the Carboniferous, nonmarine and minor marine sedimentation occurred upon the older rocks in downwarped and faulted areas. The eastern and western ends of the Minas Geofracture are marked by Triassic Fundy Group sedimentary and volcanic rocks in grabens or half-grabens.

The area to the north of the Minas Geofracture is geologically more complex and difficult to generalize. On mainland Nova Scotia, Lower to Middle Paleozoic with minor Proterozoic rocks occur in two major horst structures known as the Cobequid and Antigonish Highlands (Fig. 1-1). Adjacent to these blocks, very thick successions of Permo-Carboniferous nonmarine and minor marine sediments occur in large and small faulted and folded rift basins and/or synclinoria. Hadrynian or older Proterozoic sedimentary and volcanic rocks outcrop in much of the northern Cape Breton Highlands and along southeastern Cape Breton. Smaller basement horsts are also found scattered over the remaining area. These rocks are overlain in southeastern Cape Breton by a Lower Paleozoic sequence of Cambrian sedimentary and volcanic rocks. Granitic and minor basic plutons of Carboniferous, Devonian, and possibly locally Ordovician or older age intruded the older deformed rocks. Similar to mainland Nova Scotia, a very thick succession of Carboniferous nonmarine and minor marine sediments occur in faulted and folded basins and synclinoria that developed adjacent to and on top of the older rocks. These occur in the Canso-Bras d'Or, Sydney, Mabou and Cheticamp-Margaree areas. Much of the bedrock in Nova Scotia has been covered by a thick mantle of Pleistocene glacial deposits.

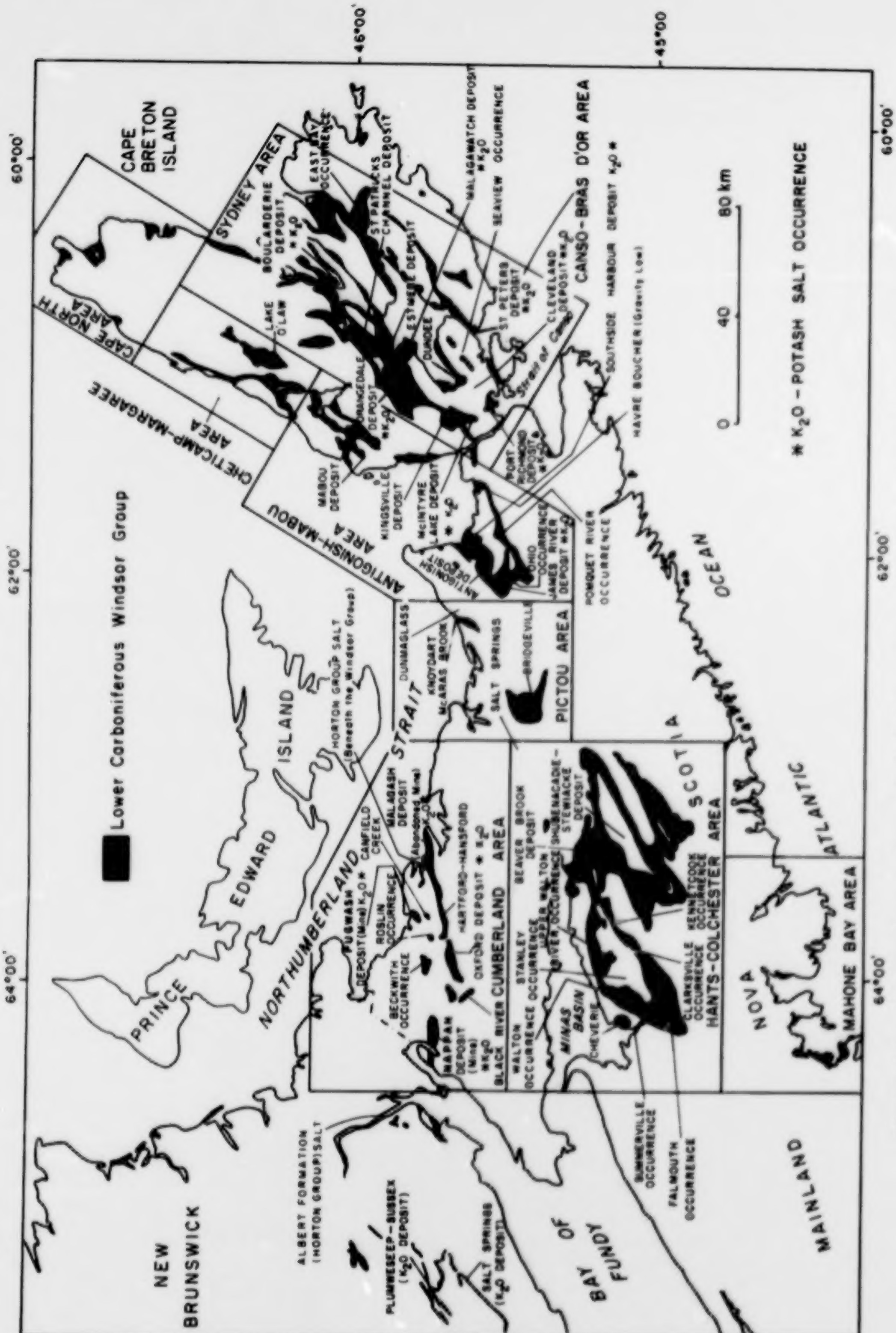


Geology after Cook, 1973 and Keppie, 1977

Figure 1-3. General stratigraphy and tectonic events of Nova Scotia.

GENERAL GEOLOGY OF SALT IN NOVA SCOTIA

The majority of the salt deposits and occurrences in Nova Scotia are confined to the Lower Carboniferous Windsor Group (Fig. 1-4), which is widely distributed throughout Atlantic Canada. However, in rocks of the Horton Group in some areas such



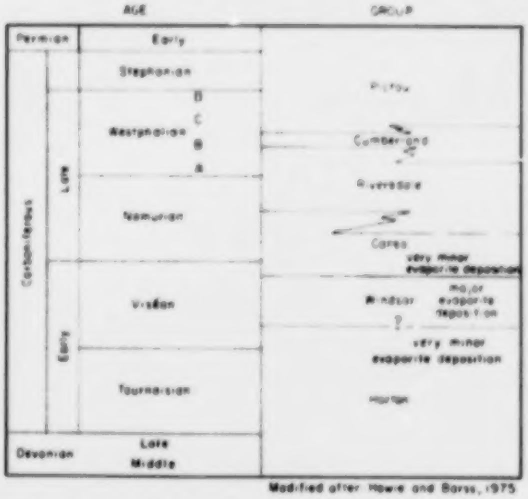
Lower Carboniferous Windsor Group
* K₂O - POTASH SALT OCCURRENCE
0
40
80 km
46°00'
45°00'
64°00'
62°00'
60°00'
NEW BRUNSWICK
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
NORTHUMBERLAND STRAIT
BAY OF FUNDY
MINAS BASIN
NOVA SCOTIA MAINLAND
ATLANTIC OCEAN
Strait of Canso
SYDNEY AREA
CAPE NORTH AREA
CHETICAMP-MARGAREE AREA
ANTIGONISH-MABOU AREA
CANSO-BRAS D'OR AREA
PICTOU AREA
CUMBERLAND AREA
HANTS-COLCHESTER AREA
MAHONE BAY AREA
ALBERT FORMATION (HORTON GROUP) SALT
PLUMWEESEEP-SUSSEX (K₂O DEPOSIT)
SALT SPRINGS (K₂O DEPOSIT)
HORTON GROUP SALT (Beneath the Windsor Group)
NAPPAN DEPOSIT (Mine) *K₂O
BLACK RIVER
BECKWITH OCCURRENCE
PUGWASH DEPOSIT (Mine) K₂O *
ROSLIN OCCURRENCE
CANFIELD CREEK
MALAGASH DEPOSIT (Abandoned Mine) *K₂O
HARTFORD-HANSFORD
OXFORD DEPOSIT * K₂O
WALTON OCCURRENCE
STANLEY OCCURRENCE
UPPER WALTON OCCURRENCE
RIVER OCCURRENCE
BEAVER BROOK DEPOSIT
SHUBENACADIE-STEWIACKE DEPOSIT
CLARKSVILLE OCCURRENCE
KENNETCOOK OCCURRENCE
CHEVERIE
SUMMERVILLE OCCURRENCE
FALMOUTH OCCURRENCE
SALT SPRINGS
McARAS BROOK
KNOYDART
DUNMAGLASS
BRIDGEVILLE
ANTIGONISH DEPOSIT
OHIO OCCURRENCE
JAMES RIVER DEPOSIT *K₂O
POMQUET RIVER OCCURRENCE
McINTYRE LAKE DEPOSIT * K₂O
KINGSVILLE DEPOSIT
MABOU DEPOSIT
ORANGEDALE DEPOSIT *K₂O
PORT RICHMOND DEPOSIT *K₂O
HAVRE BOUCHER (Gravity Low)
SOUTHSIDE HARBOUR DEPOSIT K₂O *
LAKE O'LAW
DUNDEE
ESTMERE DEPOSIT
ST PETERS DEPOSIT *K₂O
CLEVELAND DEPOSIT *K₂O
BOULARDERIE DEPOSIT *K₂O
ST PATRICKS CHANNEL DEPOSIT
SEAVIEW OCCURRENCE
MALAGAWATCH DEPOSIT *K₂O
EAST BAY OCCURRENCE

Figure 1-4. Windsor Group outcrop distribution, salt areas and deposits in Nova Scotia.

as the Cumberland area, minor amounts of salt occur in a situation similar to that in New Brunswick (Hamilton, 1961). Exploration activity to date has not been attracted to the potential continental evaporite deposits within pre-Windsor Group strata. Anomalous salt springs and saline water flows at Cheverie, Hants County, and Dunmaglass, Antigonish County (Fig. 1-4) may originate from pre-Windsor evaporites, although a fault related connection with Windsor Group evaporites is the preferred explanation.

The Windsor Group consists of interstratified marine and nonmarine sediments deposited in a complex subsiding basin system called the Fundy Basin, Fundy Epieugeosyncline (Bell, 1929, 1958), Fundy Aulacogene (Keppie, 1977) or Magdalen Basin (Keppie, 1982a,b). The Windsor Group is underlain by a thick sequence of coarse and fine terrigenous derived clastic rocks belonging to the Lower Carboniferous Horton Group although rocks assigned to this Group are as old as Middle-Late Devonian (Howie and Barss, 1975). These rocks were deposited in subsiding areas adjacent to and on top of the older deformed metamorphic and intrusive Acadian Orogen rocks whose ages range from Precambrian (Hadrynian) to Middle Devonian. The Windsor Group rocks represent the only major marine deposits in the Carboniferous sequence (Fig. 1-5) which began and ended with deposition of thick continental sediments.

Generally more than 50 per cent of the sedimentary rocks in the Windsor Group consist of evaporites, primarily anhydrite, gypsum, and halite with lesser but economically significant quantities of potash. These marine evaporite deposits precipitated from saturated seawater. The deposits occur as thick and thin beds, rythmically alternating and often intimately associated with fossiliferous marine limestone and dolostone, and red to maroon and green terrigenous clastic sediments.



Modified after Howie and Barss, 1975

Figure 1-5. Upper Paleozoic stratigraphy and evaporites in Atlantic Canada.

The Windsor Group is overlain in most areas both conformably and unconformably by a locally very thick sequence (up to 5000 m) of Upper Carboniferous nonmarine sediments consisting primarily of interbedded sandstone, siltstone, shale, and conglomerate. Groups recognized in succession from oldest to youngest are the Canso, Riversdale, Cumberland, and Pictou Groups (Fig. 1-5). The major coal deposits in Nova Scotia are found in rocks assigned to the Cumberland and Pictou Groups. A large number of formation names have been applied to subdivided units within groups and a summary of these is included in Howie and Barss (1975).

WINDSOR GROUP MAJOR CYCLES

The distribution, thickness and stratigraphic position of salt and potash within the Windsor Group were generally poorly understood until deep core drilling was conducted by mineral exploration companies in the deeper parts of the Windsor Group in the Hants-Colchester area during the mid 1970's. Prior to this, deep drilling was scarce and the holes were rarely cored completely. They were frequently located in structurally complicated areas making the stratigraphic succession difficult to determine. Detailed stratigraphic studies in the extensively drilled Shubenacadie and Musquodoboit Basins in the eastern part of the Hants-Colchester area by Giles and Boehner (1979, 1982a,b) revealed that salt (halite) occurred in association with anhydrite and siltstone at several stratigraphic positions within five major cycles of the Windsor Group (Figs. 1-6, 1-7, 1-8).

The three major cycle system originated by Giles (1978) was applied by Boehner (1984) to the Shubenacadie and Musquodoboit Basins (Figs. 1-6 and 1-7, Sections 2 and 3). It was subsequently refined and enlarged to five major cycles by Giles (1981c) who applied the system throughout Nova Scotia. The major cycle system is based primarily on detailed lithostratigraphy and paleontological data, and on comparisons to the British Dinantian Stages; it represents major transgressive-regressive phases within the Windsor Group. According to Giles (1981b), the lower boundaries of the major cycles coincide closely with lithostratigraphic, macropaleontologic, and micropaleontologic boundaries. He further concluded that the cycles were bounded by approximate time planes. To generalize the complicated lithostratigraphic nomenclature of the Windsor Group in Nova Scotia, the five major cycle system is used in this paper. The major cycle system is introduced and outlined from the Shubenacadie and Musquodoboit Basins and then extended to other Windsor Group areas in Nova Scotia.

Major Cycle 1

The major salt in the Shubenacadie Basin (Figs. 1-6, 1-7, 1-8) occurs as part of Major Cycle 1, an evaporite dominated sequence up to 500 m thick, comprising in ascending order: a thin laminated basal carbonate (3-50 m of dolostone) which locally has a thick bank facies, a thick massive to stratified anhydrite (160-300 m

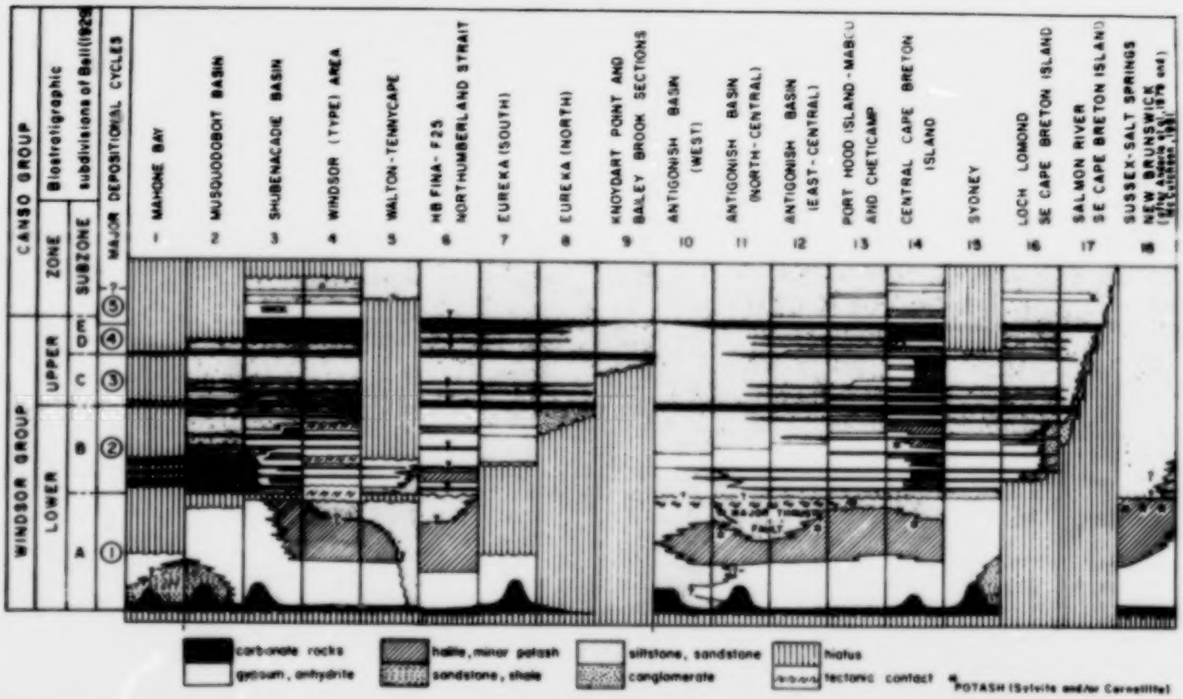

CANSO GROUP
WINDSOR GROUP
LOWER
UPPER
ZONE
SUBZONE
A
B
C
D
E
Biostratigraphic subdivisions of Bell (1929)
MAJOR DEPOSITIONAL CYCLES
①
②
③
④
⑤
1 MAHONE BAY
2 MUSQUODOBOIT BASIN
3 SHUBENACADIE BASIN
4 WINDSOR (TYPE) AREA
5 WALTON-TENNYCAPE
6 HB FINA-F25 NORTHUMBERLAND STRAIT
7 EUREKA (SOUTH)
8 EUREKA (NORTH)
9 KNOYDART POINT AND BAILEY BROOK SECTIONS
10 ANTIGONISH BASIN (WEST)
11 ANTIGONISH BASIN (NORTH-CENTRAL)
12 ANTIGONISH BASIN (EAST-CENTRAL)
13 PORT HOOD ISLAND-MABOU AND CHETICAMP
14 CENTRAL CAPE BRETON ISLAND
15 SYDNEY
16 LOCH LOMOND SE CAPE BRETON ISLAND
17 SALMON RIVER SE CAPE BRETON ISLAND
18 SUSSEX-SALT SPRINGS NEW BRUNSWICK
MAJOR THRUST FAULT
carbonate rocks
gypsum, anhydrite
halite, minor potash
sandstone, shale
siltstone, sandstone
conglomerate
hiatus
tectonic contact
*POTASH (Sylvite and/or Carnallite)
Modified after Giles 1981c

Figure 1-6. Lithostratigraphy and major cycles of the Windsor Group in Nova Scotia (see Fig. 1-7 for locations).

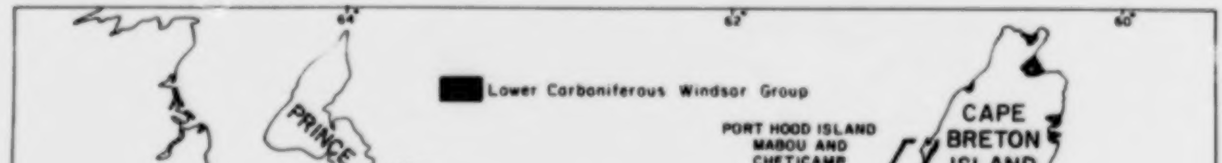

64°
62°
60°
46°
45°
Lower Carboniferous Windsor Group
PRINCE EDWARD ISLAND
NEW BRUNSWICK
CAPE BRETON ISLAND
MAINLAND NOVA SCOTIA
NORTHUMBERLAND STRAIT
BAY OF FUNDY
ATLANTIC OCEAN
PORT HOOD ISLAND MABOU AND CHETICAMP
13
NORTHUMBERLAND STRAIT H.B. FINA F-25
6
PORT HOOD I.
SYDNEY
15
KNOYDART BAILEY BROOK
9
11
14
17
16
SALMON RIVER
LOCH LOMOND
SUSSEX
18
SALT SPRINGS
EUREKA (NORTH)
8
7
EUREKA (SOUTH)
10
ANTIGONISH BASIN
CENTRAL CAPE BRETON ISLAND
WALTON TENNYCAPE
5
SHUBENACADIE BASIN
3
WINDSOR TYPE AREA
4
2
MUSQUODOBOIT BASIN
1
MAHONE BAY
KILOMETRES
0
40
80

Figure 1-7. Location map for major cycle sections in Nova Scoita (numbers refer to Fig. 1-6).

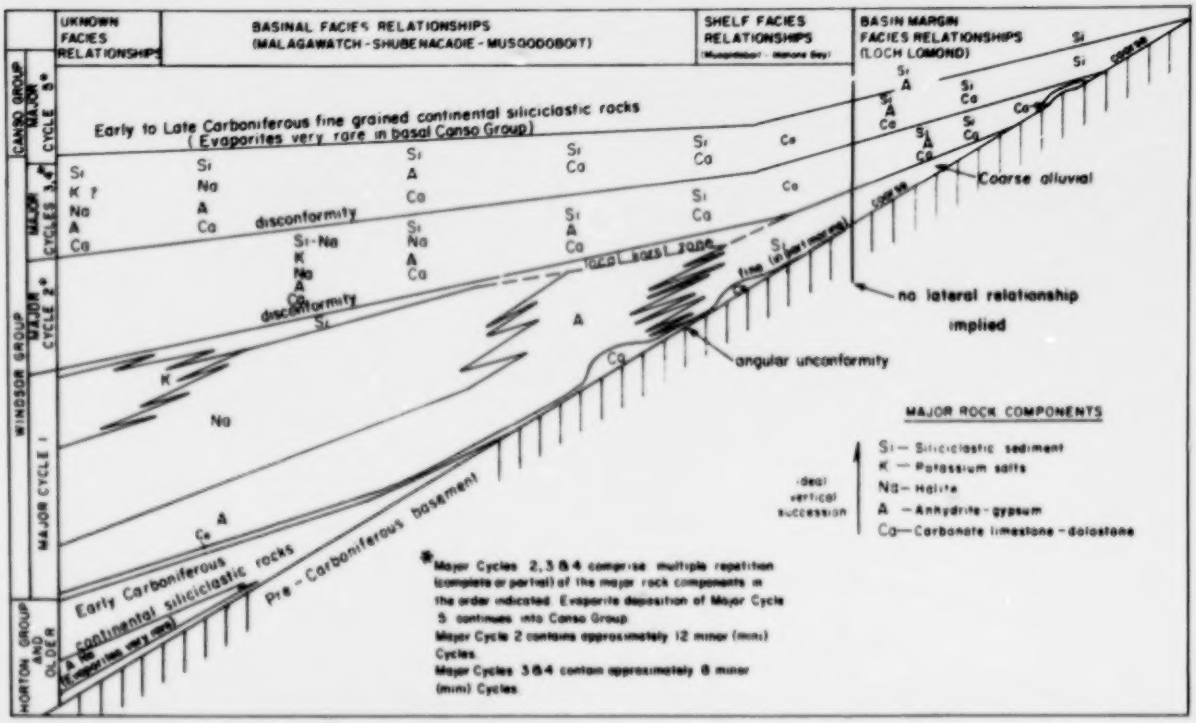

UKNOWN FACIES RELATIONSHIPS
BASINAL FACIES RELATIONSHIPS (MALAGAWATCH - SHUBENACADIE - MUSQODOBOIT)
SHELF FACIES RELATIONSHIPS
BASIN MARGIN FACIES RELATIONSHIPS (LOCH LOMOND)
CANSO GROUP
MAJOR CYCLE 5*
WINDSOR GROUP
MAJOR CYCLES 3,4*
MAJOR CYCLE 2*
MAJOR CYCLE 1
HORTON GROUP AND OLDER
Early to Late Carboniferous fine grained continental siliciclastic rocks
(Evaporites very rare in basal Canso Group)
disconformity
disconformity
local karst zone
angular unconformity
Coarse alluvial
coarse
fine (in part marine)
no lateral relationship implied
Early Carboniferous continental siliciclastic rocks
(Evaporites very rare)
Pre - Carboniferous basement
Si
K
Na
A
Ca
MAJOR ROCK COMPONENTS
ideal vertical succession
Si — Siliciclastic sediment
K — Potassium salts
Na — Halite
A — Anhydrite - gypsum
Ca — Carbonate limestone - dolostone
*Major Cycles 2, 3 & 4 comprise multiple repetition (complete or partial) of the major rock components in the order indicated. Evaporite deposition of Major Cycle 5 continues into Canso Group.
Major Cycle 2 contains approximately 12 minor (mini) Cycles.
Major Cycles 3 & 4 contain approximately 8 minor (mini) Cycles.

Figure 1-8. Schematic representation of some Windsor Group facies relationships.

thick), and stratified halite with minor siltstone and anhydrite (up to 300 m thick). In addition, a mixed siliciclastic facies, representing nearshore marine deposition, was recognized in the adjacent Musquodoboit Basin as a lateral equivalent of the anhydrite (Figs. 1-6, 1-7, and 1-8). The classic vertical (and to a lesser degree lateral) succession of marine carbonate and evaporites ranging up to halite is well represented in this area. The halite facies is confined to the Shubenacadie Basin and typically comprises banded-bedded halite with alternating light coloured pure and dark impure couplets. It also has well developed displacement and crust-like halite (shallow subaqueous to subaerial?) closely associated with green siltstone interbeds near the upper half of the section. Anhydrite interbeds (up to 5 m) are the dominant nonhalite impurity in the lower half of the halite facies. The top of Major Cycle 1 in the Shubenacadie and Musquodoboit Basins is a disconformity with karstification of the anhydrite facies at the basin edge and local reworking of anhydrite.

Based upon facies relationships, paleogeographic and paleotopographic reconstructions, Boehner (1984) concluded that Major Cycle 1 recorded very rapid marine trangression (possibly nearly instantaneous) into a pre-existing subsea level continental basin with water depths possibly up to 200 m. The thin basal laminite carbonate, although generally sparsely fossiliferous, had locally developed fossiliferous banks at higher elevations. The absence of significant transgressive facies indicates rapid transgression. The basal carbonate (cryptalgal laminite and bank facies) succession mainly records salinity stratification and progressive increase in salinity (Geldsetzer, 1978; and Giles et al., 1979). Increasing salinity produced the successive deposition of anhydrite then halite, which was localized in a shrinking basin adjacent to a contemporaneous subaerially exposed anhydrite surface. Major Cycle 1 in the Shubenacadie and Musquodoboit Basins is interpreted as generally representing regression, restriction and increasingly saline subaqueous evaporite deposition in a preformed basin.

Major Cycle 2

Major Cycle 2 in the Shubenacadie and Musquodoboit Basins is up to 160 m thick and overlies the thick evaporite sequence of Major Cycle 1. It is an assemblage of up to 12 minor transgressive-regressive cycles (minicycles) 1-15 m thick, consisting of laterally extensive transgressive-regressive marine carbonates, continental redbeds (in subequal proportions) with a variable, but generally dominant proportion of evaporite (greater than 50%) including anhydrite and minor halite. A typical saline minicycle comprises in ascending order: transgressive then regressive carbonate facies, anhydrite, halite, ± redbeds (Fig. 1-7). Boehner (1984) described the anhydrite as ranging from nodules in matrices of siltstone or carbonate grading to coalescing nodular mosaic. The anhydrite associated with stratified halite is massive to locally laminated and halitic. The nodular anhydrite both in situ and as clasts was interpreted by Boehner (1984) as recording a diagenetic sabkha-type origin in low relief prograding coastal mud flats. The closely associated laminated and massive anhydrite and bedded halite were inferred to have been precipitated in shallow hypersaline pans and lagoons spatially associated with the sabkha environment.

Major Cycles 3, 4 and 5

In the Shubenacadie and Musquodoboit Basins Major Cycles 3, 4 and 5 disconformably overlie Major Cycle 2. Major Cycle 5 includes the highest Windsor Group marine carbonate member and the transitional evaporites (anhydrite and halite) locally present at the base of the Canso Group. These Major Cycles, comprising up to 9 minicycles, are lithologically similar to Major Cycle 2 and have a combined thickness of up to 160 m. They differ from Major Cycle 2 mainly in the decreased proportion of evaporite (less than 30%). Typical saline minicycles include in ascending order: transgressive then regressive carbonate facies, anhydrite and redbeds (Fig. 1-8). Halite is known only in Major Cycle 5 in the Shubenacadie Basin. The continuation of evaporite deposition including anhydrite and halite of Major Cycle 5 into post Windsor Group rocks (Canso Group) is interpreted as representing the terminal phase of marine invasion and evaporite deposition in restricted continental successor basins with uncertain marine influence.

The dramatic change from the single progressive evaporite sequence of Major Cycle 1 to the repeated minicycles within Major Cycles 2 to 5 was interpreted by Boehner (1984) to have resulted from the basin infilling and topographic leveling by the thick evaporites of Cycle 1. The resulting surface of low relief and gentle slope favoured shallow water and diagenetic evaporite deposition during regressive episodes following repeated marine invasions. Boehner (1984) recognized decreased and more localized evaporite deposition within successively younger major cycles of the Shubenacadie and Musquodoboit Basins.

Major Cycles Distribution and Correlation

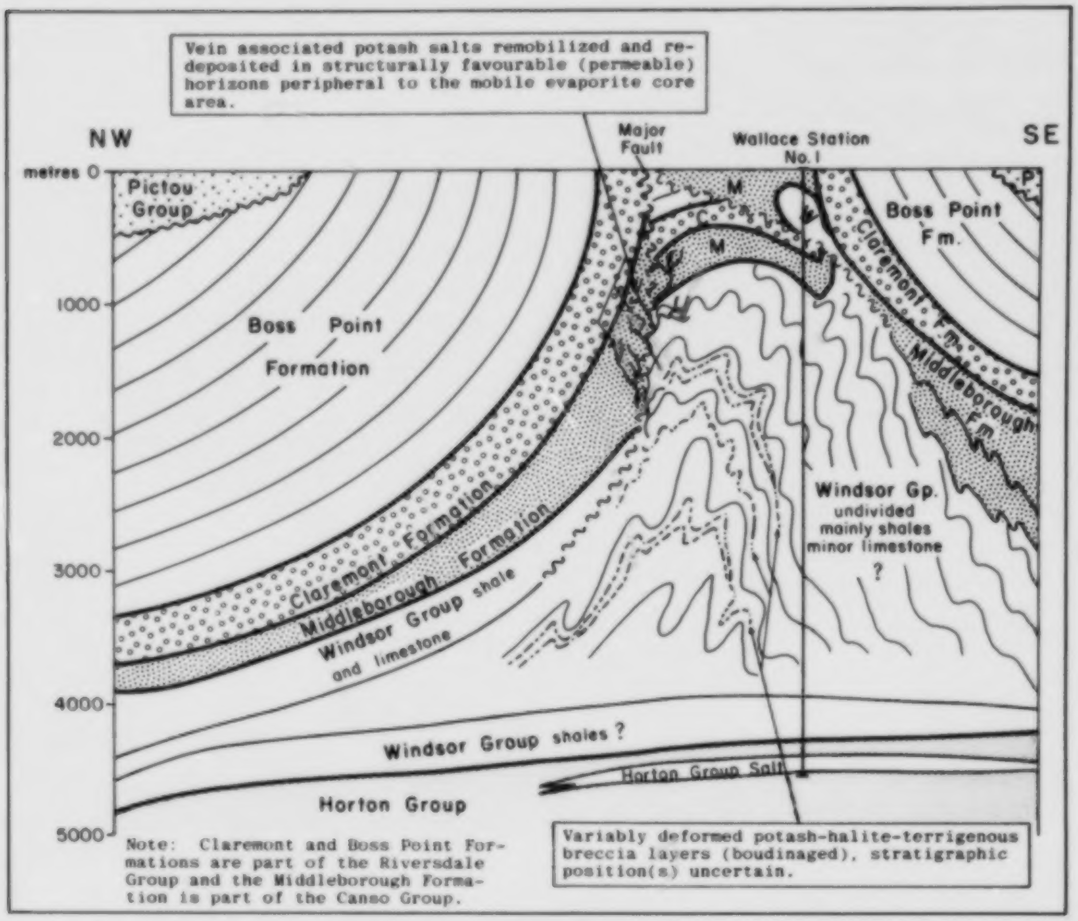
The major cycle framework outlined from the Shubenacadie and Musquodoboit basins is generally applicable to many Windsor Group outcrop areas in Nova Scotia (Figs. 1-6 and 1-7). Major facies changes and stratigraphic onlap locally complicate the picture, especially in areas near basement blocks such as Mahone Bay, Eureka and Loch Lomond (Figs. 1-6, 1-7, Sections 1, 8 and 16; and Fig. 1-8). Typical Major Cycle 1 rocks are widespread throughout Nova Scotia and are well represented in the Antigonish-Mabou, Canso-Bras d'Or and Sydney areas where their thickness ranges from 300 to 600 m. Redbeds are locally developed in some areas including western Hants-Colchester, Antigonish-Mabou, and Canso-Bras d'Or (Figs. 1-6 and 1-7, Sections 4, 5, 6, 10, 11, 12, 13 and 14). The redbeds are closely associated with the halite facies. Halite is known to occur with Major Cycle 1 in most areas and it forms the most important salt resource in Nova Scotia. Boehner (1980a) reported that the Shubenacadie-Stewiacke deposit in the Hants-Colchester area contains an estimated geological resource of 50 billion t.

Potash salt, sylvite and minor carnallite are known to be associated with halite in Major Cycle 1 in the Antigonish and Canso-Bras d'Or areas (Figs. 1-6, 1-7 and 1-8, Sections 10, 11, 12 and 14). Although encouraging for further exploration, economic quantities have yet to be discovered. Potash salts are not known to occur on the Nova Scotia Platform south of the Minas Geofracture. Major Cycle 1 rocks in this area were inferred by Giles (1981b) to have been deposited adjacent to seaways connected to a major Visean sea through a shallow marine carbonate shelf on the Nova Scotia Platform. Successive Carboniferous structural basins in a northwesterly direction generally contain increasingly saline evaporite suites indicating significant lateral facies change and important paleogeographic control on evaporite deposition. Paleogeographic reconstructions across the Minas Geofracture are uncertain at this time.

The distribution, thickness and facies variation of evaporites in Major Cycle 1 are unknown in most areas because of the scarcity of deep drilling. Stratigraphic thicknesses of up to 600 m are present in some areas with the thickest sections in the highly deformed saline Windsor Group facies of the Canso-Bras d'Or area. Major Cycle 1 is the major target for potash exploration in Nova Scotia as it is in New Brunswick (Fig. 1-6, Section 18).

The thick halite-anhydrite-siltstone sequence in the highly deformed diapiric Windsor Group in the Cumberland area is of uncertain stratigraphic assignment (Fig. 1-9). Drillhole sections and mine stratigraphic sections (Evans, 1972) are incomplete and their relationship to outcrop sections of Bell (1958) are uncertain. The stratigraphy of the evaporites in the Cumberland area is virtually unknown and therefore stratigraphic comparisons to well established sections in other areas is not yet possible.

The basal Windsor Group in the Anschutz Wallace Station No. 1 well (Fig. 1-9) drilled near Malagash comprises a thick sequence of cherty-siliceous shales. These relatively undisturbed, gently dipping shales may represent deep water sediments. The Cumberland area is geologically important because it is close to the New Brunswick Platform area where economic potash deposits have been discovered in Major Cycle 1 of the Windsor Group (Figs. 1-6 and 1-7, Section 18). Potash salts, sylvite and carnallite have been reported from all known salt deposits in the Cumberland area, but not in economic quantities (Fig. 1-4). Structural complexity and geological uncertainty are major factors that have hindered potash exploration in this area. Potash salts are found in two major settings (Fig. 1-9) associated with the Windsor Group evaporite diapirs: 1) as mudstone-halite breccia and boudins in intensely folded stratified layers, and 2) as remobilized secondary veins and stockworks peripheral to and/or within the diapir. The stratigraphic position of these potash occurrences is unknown.



Vein associated potash salts remobilized and redeposited in structurally favourable (permeable) horizons peripheral to the mobile evaporite core area.

Variably deformed potash-halite-terrigenous breccia layers (boudinaged), stratigraphic position(s) uncertain.

Note: Claremont and Boss Point Formations are part of the Riversdale Group and the Middleborough Formation is part of the Canso Group.

NW
SE
Major Fault
Wallace Station No. 1
metres 0
1000
2000
3000
4000
5000
Pictou Group
Boss Point Formation
Claremont Formation
Middleborough Formation
Windsor Group shale and limestone
Windsor Group shales ?
Horton Group Salt
Horton Group
M
C
P
Boss Point Fm.
Claremont Fm.
Middleborough Fm.
Windsor Gp. undivided mainly shales minor limestone
?

Figure 1-9. Schematic cross-section through the Malagash Anticline illustrating structural complexity of the diapir and settings for potash salts.

Major Cycle 2 is more widespread than Major Cycle 1. Major Cycle 2 displays major facies change regionally ranging from evaporite dominated to terrigenous dominated. It locally oversteps Major Cycle 1 to onlap onto pre-Carboniferous basement rocks (Fig. 1-8) in marginal basin areas including Loch Lomond and Salmon River (Figs. 1-6 and 1-7, Sections 16 and 17, Boehner, 1983). Similar changes were indicated by Giles (1981c) in the Eureka and Mahone Bay areas (Figs. 1-6 and 1-7, Sections 1 and 8). The Mahone Bay area is similar to the Musquodoboit Basin (Fig. 1-6, Section 2). Shallow marine shelf facies in Major Cycles 1, 2 and 3 indicated that these areas may have been proximal to a seaway connecting the Viséan inland sea on the Nova Scotia Platform to the Major Viséan sea to the southeast (Giles, 1981c). The major evaporite deposition appears to have been localized in deeper, more northerly parts of the inland sea.

Halite stratigraphically above Major Cycle 1 was first recognized with several carbonate-anhydrite minicycles within Major Cycle 2 in the Shubenacadie Basin (Figs. 1-6, 1-7, Section 3). The stratified halite and interbedded anhydrite horizons rarely exceeded thicknesses of 15 m, but subsequently thicker and more numerous halite beds have been confirmed in the highly deformed sections in the Canso-Bras d'Or area (Giles, 1981a; and Dekker, 1982a,b). Exploration drilling at McIntyre Lake, Malagawatch and Orangedale has intersected potash (sylvite and minor carnallite) in one carbonate-anhydrite-halite minicycle within Major Cycle 2. The presence of potash, although in subeconomic quantities in at least one horizon in this cycle, was previously unknown and may provide an additional potash exploration target.

Major Cycle 2 at Malagawatch is dominated by halite and is up to three times (500 m versus 160 m) as thick as in the Hants-Colchester area. Approximately 45 per cent of the Malagawatch section is halite and 30 per cent anhydrite. Corresponding sections in the Shubenacadie Basin are 14 per cent halite and 51 per cent anhydrite.

The majority of the increase in statigraphic thickness at Malagawatch is contributed by the halite (230 m versus 22 m).

Major Cycles 3, 4 and 5 are more widely distributed than Cycles 1 and 2 (Fig. 1-7). Onlap relationships have been documented by Boehner (1983) near Loch Lomond and Salmon River (Figs. 1-6 and 1-7, Sections 16 and 17) in southeastern Cape Breton Island and near Knoydart Point in northeastern mainland Nova Scotia (Figs. 1-6 and 1-7, Section 9) by Giles (1981c). Although salt was locally present in Major Cycle 5 in the Shubenacadie Basin it did not occur in Major Cycles 3 and 4. It was found, however, to be a substantial component in Major Cycles 3 and 4 in the Canso-Bras d'Or area. Here the Major Cycle 3 section is nearly four times as thick as corresponding sections in the Shubenacadie Basin (270 m versus 70 m) and consists of 34 per cent halite and 28 per cent anhydrite. Corresponding values are 0 per cent and 10 per cent, respectively, in the Shubenacadie Basin. Similar to Major Cycle 2 in the Malagawatch area, most of the increase in thickness is contributed by the halite.

Unfortunately, data are incomplete to allow comparisons with Major Cycles 3 and 4 in other areas such as Antigonish-Mabou and Cumberland. Salt facies have not been confirmed in Major Cycles 2, 3, 4 and 5 in these areas. Anhydrite is present and the presence of salt (possibly with potash) may be established by deep basin drilling.

SALT DEPOSITS AND OCCURRENCES

The present distribution of Carboniferous rocks in Nova Scotia is controlled by postdepositional tectonism and erosion. These factors, together with high angle transcurrent, dip slip and low angle faulting, make a precise outline of the original sedimentary sub-basins difficult. The relationship of the present structural basins or synclinoria to the original depocentre is sometimes uncertain. For these reasons the salt areas of Nova Scotia described in this report are named as present day geographical and structural areas that may or may not correspond to the original sedimentary sub-basins outlined by Bell (1958).

The five areas with known salt deposits (Fig. 1-4) found in Nova Scotia are the Hants-Colchester, Cumberland, Antigonish-Mabou, Canso-Bras d'Or, and Sydney areas. In addition, there are four areas underlain by Windsor Group rocks where salt may be present, but has not been established by drilling. These include the Mahone Bay, Pictou, Cheticamp-Margaree, and Cape North areas. The salt and potash resources of the Province are shown on Figure 1-10 (in the back pocket).

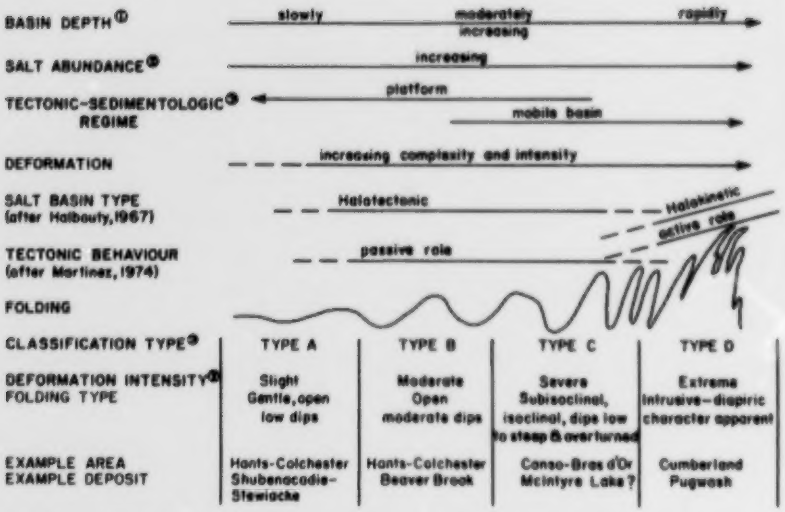
GENERAL TECTONICS AND STRUCTURAL GEOLOGY

Keppie (1982a) indicated that the Carboniferous rocks in the Magdalen Basin and locally in adjacent areas were deformed between Early Westphalian and Late Triassic times. This deformation was attributed to movement on the Minas Geofracture associated with the Hercynian Orogeny. Deformation within the Magdalen Basin was most intense along its margins and was accompanied by diapiric structures in basinal settings such as the Cumberland area. Subsidiary strike slip and dip slip movement on major systems of northeasterly trending transcurrent faults produced local deformation in narrow Carboniferous areas bounded by fragmented basement blocks. This situation is common in the Canso-Bras d'Or area. Locally severe deformation including gravity sliding occurred on the relatively stable Nova Scotia Platform. In the deeper basins differing fold geometry and structural style may be expected between pre- and post-Windsor Group rocks.

Carboniferous rocks were deposited in two principal tectonic settings: 1) on relatively stable platforms i.e Nova Scotia and New Brunswick Platforms (Fig. 1-7), and 2) within an intervening fragmented pull apart area named the Magdalen Basin (Keppie, 1982b). These settings developed, beginning in the Middle-Late Devonian, as part of transpression tectonics (Keppie, 1982a,b). Prominent transcurrent wrench faulting produced a molassic succession characterized by complicated facies variation and structural complexity. The easily mobilized evaporite deposits of the Windsor Group have locally undergone severe deformation and thickening, often resulting in large wall and plug-like diapiric intrusions. The most severe deformation is characterized by tortuous folding with isoclinal, recumbent to upright geometry, normal and reverse faulting, gravity sliding, and extensive plastic flow of salt and anhydrite rocks. Locally, as in the Cumberland area, unconformities are evident where younger Carboniferous units flank the structure (Fig. 1-9) indicating that the movement occurred over a period of time.

In Nova Scotia, Windsor Group evaporites including salt and associated potash occur in a variety of structural situations that have been classified in Figure 1-11. The locations of salt and potash are based primarily upon the degree of structural complexity and thus each type is part of a continuous spectrum. The structural complexity is controlled largely by location with respect to the major faults, severity of tectonism, volume of salt and depth of burial. The relatively undisturbed stratified deposits (Types A and B) generally occur in the platform synclinoria marginal to the central mobile area (Figs. 1-11, 1-12). At the opposite end of the spectrum, structurally complex halotectonic type deposits resulting from compressive tectonic forces (Halbouty, 1967, p. 2) are represented in the Canso Bras d'Or area (Types C and D). Intensely deformed deposits (at least in the final stage of development) from halokinetic (isostatic) salt movement, (Halbouty, 1967, p. 2) are present in the Cumberland area (Figs. 1-10, 1-11). Here Windsor Group evaporites occur as wall and dome, diapiric anticlinal intrusions. These intrusions appear to be restricted to areas of thick Carboniferous sedimentation and may occur in the Mabou and the Canso-Bras d'Or areas (Figs. 1-10, 1-11).

Moderate to strong deformation is present in the western and northern parts of the Hants-Colchester area, the Antigonish area and parts of


BASIN DEPTH ①
slowly
moderately
rapidly
increasing
SALT ABUNDANCE ②
increasing
TECTONIC-SEDIMENTOLOGIC ③ REGIME
platform
mobile basin
DEFORMATION
increasing complexity and intensity
SALT BASIN TYPE (after Halbouty, 1967)
Halotectonic
Halokinetic
TECTONIC BEHAVIOUR (after Martinez, 1974)
passive role
active role
FOLDING
CLASSIFICATION TYPE ③
TYPE A
TYPE B
TYPE C
TYPE D
DEFORMATION INTENSITY ②
FOLDING TYPE
Slight
Gentle, open low dips
Moderate
Open moderate dips
Severe
Subisoclinal, isoclinal, dips low to steep & overturned
Extreme
Intrusive—diapiric character apparent
EXAMPLE AREA
EXAMPLE DEPOSIT
Hants-Colchester
Shubenacadie-Stewiacke
Hants-Colchester
Beaver Brook
Canso-Bras d'Or
McIntyre Lake ?
Cumberland
Pugwash

① reflects potential geostatic loading influence.

② evaporite tectonics are complicated by heterogeneous lithology, facies variation and uneven distribution of salt in the Windsor Group.

③ any type may occur in simple or complex graben or half graben basins.

Figure 1-11. Summary of evaporite deposit classification in Nova Scotia.

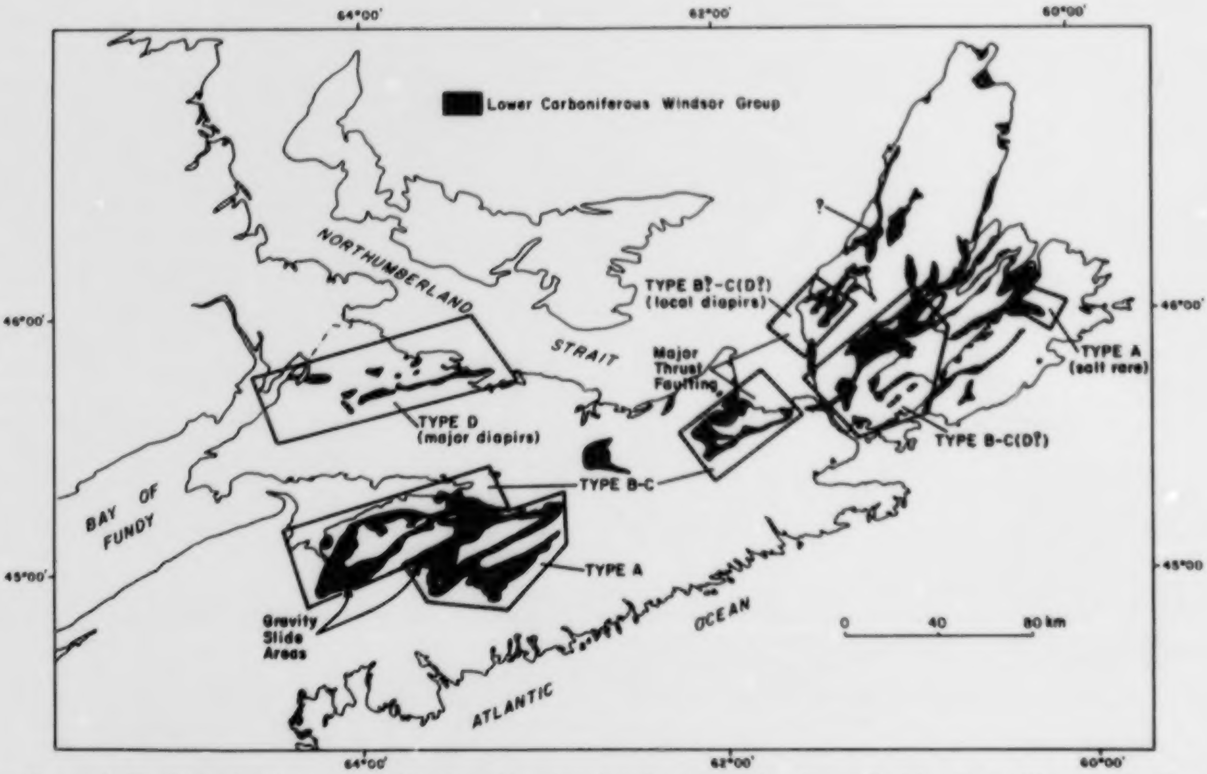

64°00'
62°00'
60°00'
46°00'
45°00'
Lower Carboniferous Windsor Group
NORTHUMBERLAND
STRAIT
BAY OF FUNDY
ATLANTIC
OCEAN
TYPE B?-C(D?)
(local diapirs)
Major Thrust Faulting
TYPE A
(salt rare)
TYPE B-C(D?)
TYPE D
(major diapirs)
TYPE B-C
TYPE A
Gravity Slide Areas
?
0
40
80 km

Figure 1-12. Distribution of salt deposit structural types in Nova Scotia (see Fig. 1-11 for explanation of salt deposit structural types).

the Bras d'Or area in central Cape Breton (Types B and C). In these areas the Windsor Group salt occurs in variably faulted synclinoria where thickening of the evaporites is generally minor. Thickening where present appears to be limited to local "welts" in anticlinal or synclinal cores or as fault bounded synclinoria between basement blocks. A major thrust fault is inferred to occur at the top of Major Cycle 1 in the Antigonish Basin (Boehner and Giles, 1982). This fault, which may be related to major strike slip faulting, is suspected to occur in other areas including Mabou in western Cape Breton Island. Slightly deformed, stratified salt (Type A) is not common in Nova Scotia although in the eastern part of the Hants-Colchester area (Shubenacadie-Stewiacke deposit) there is a major deposit of relatively undisturbed salt. This area of relatively thin sedimentary cover was probably subject to less intense deformation because it is outside the mobile central belt of the Magdalen Basin. Large and small scale recumbent fold structures with multiple repetition of stratigraphic units have been described locally in parts of the Hants-Colchester area (Figs. 1-4, 1-10, 1-11) by Giles (1977), Boehner (1977c) and Geldsetzer et al. (1980). This folding is inferred to have been related to tectonic uplift, detachment and gravity sliding on the top of Major Cycle 1 evaporites (especially the salt).

SALT DISSOLUTION FEATURES

Cap rock development of the Gulf Coast type is not known to occur in association with the Windsor Group in Nova Scotia. Residual collapse breccia is common in areas where saline Windsor Group comes to the surface. The residual breccia is well developed at Pugwash and Nappan where blocks of gypsum and carbonate resistates are found in poorly to unconsolidated mud forming an irregular cap to the evaporite diapirs. Giles (1981a) described telescoped collapse brecciated sections of highly deformed saline Windsor Group in the McIntyre Lake area of Cape Breton Island. In this area, halite has been preferentially dissolved to a depth of 200-300 m leaving the original stratigraphic succession intact but thinned with the relatively insoluble brecciated anhydrite-gypsum and carbonate infiltrated by mudstone. A similar situation was described in the Malagawatch area by Dekker (1982a, b). Salt removal, residual accumulation and collapse brecciation may be expected in the vicinity of faults, permeable strata and in areas where the Windsor Group outcrops. The absence of salt springs and seeps in many areas of these features indicates salt dissolution has been reduced or halted, possibly by the sealing action of residual clay and mud. The widespread occurrences of salt springs, seeps, and saline formation water indicate that the salt areas are not completely sealed.

HISTORY OF POTASH EXPLORATION IN NOVA SCOTIA

INTRODUCTION

Exploration activity for potash in Nova Scotia reached an all time high following reports of a potash occurrence in a borehole on the Chevron Standard-Irving Oil Ltd. property near Malagawatch, Cape Breton Island (Dekker, 1982a,b; Fig. 1-4). Exploration was further encouraged by the discovery of ore grade potash in the Windsor Group evaporites of New Brunswick in the early 1970's. Two deposits are under development in New Brunswick: one near Sussex by the Potash Company of America (Fig. 1-4) and the other near Salt Springs by Denison Mines (after International Minerals and Chemical Corporation (Canada) Ltd). Although these are the first two economic deposits to be developed in southeastern Canada, the presence of potash was recorded shortly after the turn of the century.

EARLY WORK

The first confirmation of potash mineralization associated with salt in Nova Scotia was made in the early workings of the Malagash Mine in 1919 (Hayes, 1920). Although the grade and extent of the potash was later discovered to be limited and subeconomic, the possibility of finding economic deposits in other areas could not be overlooked.

Hayes (1920) described the geology of the Malagash Mine area and reported that the potash encountered in the upper mine workings occurred as a lenticular deposit of pink and yellow-green sylvite in a matrix of halite. The thickness and grade were highly variable, generally less than 1.5 m thick and less than 10 per cent potash. Ellsworth (1926) described the chemistry of the potash horizon in the upper levels of the Malagash Mine and reported that the sylvite lenses were associated with red coloured salt (hematitic) and that magnesium salts were virtually absent. Messervey (1950) reported that drilling and crosscutting at lower levels in the Malagash Mine yielded a proven tonnage of 80 000 tons at 8 per cent KCl with an additional 145 000 tons reasonably assured.

Potash is also present in the Nappan area (Fig. 1-4). Roliff (1932) reported that several samples of salt cuttings from the Amherst No. 1 oil well drilled by Imperial Oil Ltd. contained greater than 1 per cent (calculated) KCl. Two samples from near the top of the salt section contained 4.50 and 4.42 per cent KCl (calculated). Description of this well indicated the presence of bitter and reddish salts at 982.1 m - 985.2 m (3220-3230 ft.) which corresponded to the potash in the Malagash Mines. Analyses from this section of the Amherst well indicate 1.18 per cent KCl (calculated).

The first major exploration for potash was initiated in 1930 when a regional survey was conducted by Hayes (1931) on behalf of Imperial Chemical Industries Ltd. of New York. This survey involved sample analyses of salt springs and geological mapping. Exploration drilling was not undertaken.

In the late 1950's and early 1960's systematic gravity surveys of Carboniferous outcrop areas in parts of Cumberland, Colchester, Hants and Pictou Counties were carried out by the Nova Scotia Research Foundation. Prior to these, only local gravity or seismic surveys were undertaken by petroleum exploration companies in the Malagash-Wallace and Mabou areas. These and subsequent geophysical surveys are of great assistance in assessing the presence and depth of salt in the various Windsor Group outcrop areas in the Province. Major gravity anomalies (minima) were shown to be invariably coincident with known Windsor Group outcrop suspected to contain salt. A large number of these anomalies in the Hants-Colchester and Cumberland areas were drilled to relatively shallow depths in a sulphur exploration program by Scurry Rainbow Oil Ltd. (1967). Although the company was not successful in locating sulphur or potash, minor occurrences of salt were recorded. Additional deep drilling will be required to properly evaluate the geophysical anomalies of these areas.

RECENT EXPLORATION

Exploration drilling for salt in Pugwash resulted in the opening of the Pugwash Mine in 1958 by the Canadian Salt Company. Potash salts were encountered in some of the exploration drillholes, and later in the mine, in thin discrete layers within the highly deformed salt. These potash salt layers, studied by the Nova Scotia Research Foundation (1962) and Aumento (1964), were found to occur in subeconomic grades and thicknesses typically less than 5 per cent K_2O over intervals of a few feet. The principal potassium minerals, according to Aumento (1964), were carnallite with lesser amounts of sylvite in association with halite and fine siliciclastic material.

The Nova Scotia Research Foundation (1962) indicated three distinct types of potash salt occurrences in the Pugwash Mine area. The first occurs as matrix cement with halite in breccia and clay-mudstone. The second occurs as tiny blebs in salt bands located within a few feet of a breccia zone. The third occurs as veins with red orange fibrous crystals of halite with clay. The complex isoclinal folding of Windsor Group evaporites in Pugwash Mine was described in detail by Evans (1967, 1972). He indicated the potash zones of "carnallite breccias" and sylvite occur mainly near the inferred base of the section which contains the siliciclastic-rich salt.

Baar (1966) reported the bromine content of Windsor Group salt could be used as an indicator of the degree of brine concentration of the original precipitates. Potash salt is an end product in evaporite precipitation, so the more concentrated the brine the more favourable the environment for the accumulation of potash. According to Baar, (1966) from his studies of salt deposits in Germany, when primary potash precipitation occurs the Br/NaCl ratio rises from 0.007 to 0.02.

From his studies in Nova Scotia, Baar (1966) concluded that brine concentrations may have reached primary potash mineral deposition in the lower part of the Pugwash Mine section and also in the lower most part of the salt section at Nappan (Fig. 1-4). Evidence was found in the Pugwash Mine for bromine alteration as the result of migrating solutions from a pre-existing enriched source during deformation. These migrating fluids produced secondary potash minerals within permeable hosts and their Br content was at disequilibrium with enclosing rocks. Baar (1966) further concluded that potash accumulation probably occurred in the deepest part of the Cumberland Basin. In the Antigonish-Mabou and Minas Basin areas the study did not indicate a high brine concentration.

In 1966 the Province of Nova Scotia, with funding from the Atlantic Development Board, initiated a potash exploration program in Cumberland County. Specific targets were the extensions of the potash zone found in the Malagash Salt Mine to deeper areas along the strike of the Malagash Anticline. The Wallace No. 1 and No. 2 drillholes intersected steeply dipping (55°) subeconomic grade potash salts mixed with halite, siltstone and mudstone. The maximum grade thickness was 4.1 per cent K_2O over 42.4 m (139 ft.) or 5.05 per cent K_2O over 29.9 m (98.2 ft.) at depths of up to 1200 m. Goudge (1967) suggested that because the Wallace cores were drilled using a fluid not saturated in potash (sylvite or carnallite), the analyses might be low because of incomplete recovery due to leaching.

Evans (1970c) described the genesis of the potash in the Wallace cores and reported that sylvite was the dominant potassium mineral. The sylvite occurred with halite and minor carnallite in a matrix of dense clay mudstone or with halite in a halite mudstone breccia.

A petrographic study by Evans (1970c) indicated sylvite occurred as a secondary product of leaching of carnallite with abundant halite pseudomorphs after carnallite. A replacement series of halite after sylvite after carnallite was described with talc, quartz, and hematite developed as reaction products from released Mg with siliciclastics. Evans (1970c) concluded that the original sediment was probably a carnallite and halite bearing clay. This was later elevated and brecciated during diapirism.

From 1967 until the early 1970's there was very little exploration activity for potash until trace amounts of potash were intersected in the western part of the Antigonish structural basin by Millimor-Rogers Sydicate (1974) and Amax Exploration Ltd. (1975) (Fig. 1-4). Stewart (1976) studied the core from the James River drilling and reported the presence of sylvite after carnallite in halitic mudstone in drillhole AP-1-74. A maximum value of 6.25 per cent K_2O is indicated in selected samples taken from a mineralized zone 1.3 m in length with the greatest concentration over a 10 cm section in the centre of the zone. The potash zone was concluded by Stewart (1976) to occur within the major A Subzone evaporite section at the base of the Windsor Group (Fig. 1-13).

In 1975 potash exploration drilling was conducted in the Shubenacadie area by Noranda and St. Joesph Exploration Companies. Potash was not reported, but a very large salt deposit was established.

Since the late 1960's, the Strait of Canso and central Cape Breton Island (Canso Bras d'Or area) have been sites of renewed salt exploration activity (Fig. 1-4). The most recent activity is by Chevron Canada Ltd. and Noranda Exploration Company Ltd. directed at (Dekker, 1982a,b) potash exploration in the Bras d'Or Lakes area.

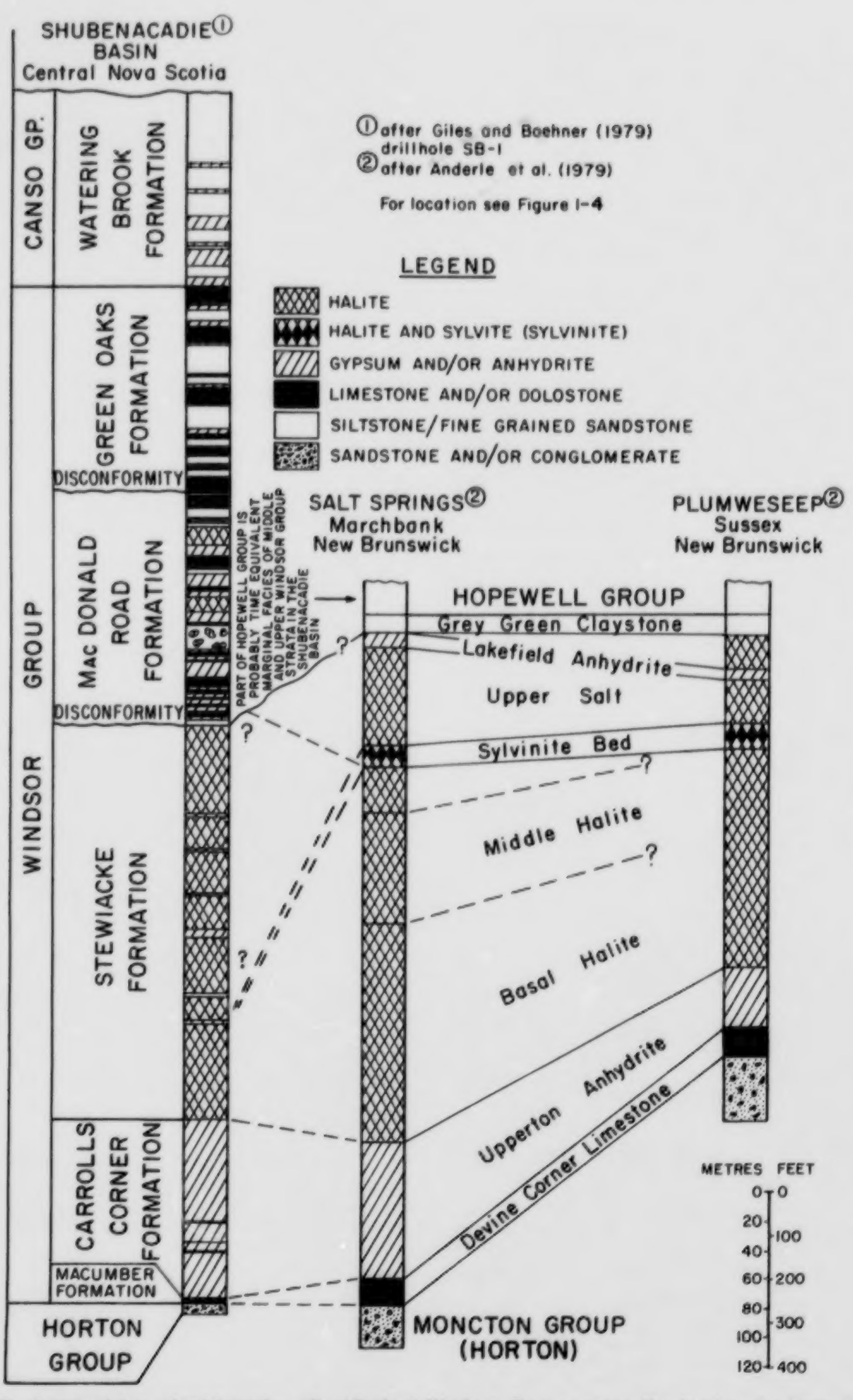

SHUBENACADIE①
BASIN
Central Nova Scotia
CANSO GP.
WATERING BROOK FORMATION
GREEN OAKS FORMATION
DISCONFORMITY
MAC DONALD ROAD FORMATION
DISCONFORMITY
WINDSOR GROUP
STEWIACKE FORMATION
CARROLLS CORNER FORMATION
MACUMBER FORMATION
HORTON GROUP
①after Giles and Boehner (1979) drillhole SB-1
②after Anderle et al. (1979)
For location see Figure I-4
LEGEND
HALITE
HALITE AND SYLVITE (SYLVINITE)
GYPSUM AND/OR ANHYDRITE
LIMESTONE AND/OR DOLOSTONE
SILTSTONE/FINE GRAINED SANDSTONE
SANDSTONE AND/OR CONGLOMERATE
PART OF HOPEWELL GROUP IS PROBABLY TIME EQUIVALENT MARGINAL FACIES OF MIDDLE AND UPPER WINDSOR GROUP STRATA IN THE SHUBENACADIE BASIN
SALT SPRINGS②
Marchbank
New Brunswick
PLUMWESEEP②
Sussex
New Brunswick
HOPEWELL GROUP
Grey Green Claystone
Lakefield Anhydrite
Upper Salt
Sylvinite Bed
Middle Halite
Basal Halite
Upperton Anhydrite
Devine Corner Limestone
MONCTON GROUP (HORTON)
?
METRES FEET
0 0
20 100
40
60 200
80 300
100
120 400

Figure 1-13. Comparative stratigraphy of selected Windsor Group evaporite basins in Nova Scotia and New Brunswick.

Interesting, but apparently subeconomic showings of potash salts have been reported in the evaporite sections drilled at McIntyre Lake (Hale, 1972; and Giles, 1981a) and also at Port Richmond. Maximum values reported are 14.11 and 13.34 per cent K_2O over intervals of 30 cm (1 ft.). Core logs of the evaporite sections in this hole commonly report the occurrence of the potash salts carnallite and sylvite. Although the grades and thicknesses are subeconomic, the occurrence of the potash salts within the interstratified halite, anhydrite, siltstone and marine limestone, typical of the middle and upper parts of the Windsor Goup (Figs. 1-8 and 1-13), may be important to further exploration concepts applied to Nova Scotia evaporite basins.

NEW BRUNSWICK OCCURRENCES

The geology of two potash deposits in Windsor Group evaporites in New Brunswick have been described by Kingston and Dickie (1979) and Anderle et al. (1979). According to Kingston and Dickie (1979), the deposits at Sussex and at Salt Springs have similar stratigraphy (Fig. 1-13) and mineralogy but slightly different tectonic histories. The potash ore zone is a sylvite-halite mixture (sylvinite) situated near the top of a thick carbonate-anhydrite-halite evaporite section that may be over 400 m thick. This major evaporite sequence is overlain by a thinner section of interstratified halite and anhydrite and then terrigenous rocks (Fig. 1-13). In the Sussex area (Figs. 1-4) the structural configuration is anticlinal (Anagance Axis) and at Salt Springs is synclinal (Marchbank Syncline). In both areas, the potash horizons display varying degrees of deformation and structural complexity. In the case of Sussex, the potash zone is apparently absent at the crest of the anticline and is postulated by Kingston and Dickie (1979) to have been removed by circulating groundwater, in a process referred to as "subrosion".

NOVA SCOTIA COMPARISONS

A clear, detailed stratigraphic correlation between Nova Scotia's evaporite basins (based upon the Shubenacadie area) and New Brunswick's evaporite basins is not possible with the available data. Similarities do exist, however, especially in the lower most parts of the sections (Fig. 1-13) where a major depositional succession of carbonate followed by halite is evident. Within the Shubenacadie Basin, for comparison, potassium salts are not present. The evaporite cycle, including potassium salts, appears to be more complete in the case of the New Brunswick sections. Windsor Group basins in which this major evaporite cycle is complete (up to potassium salt deposition) are major exploration targets. The section above the major evaporite succession is not readily correlative (Fig. 1-13). Hypothetically, the MacDonald Road and Green Oaks Formations may be represented, in whole or in part, by the upper salt and the Hopewell Group section in New Brunswick. In Nova Scotia potassium salts were deposited at higher levels in the cyclic middle and upper parts of the Windsor Group (Fig. 1-8).

Potash salts are known to be present only in Windsor Group rocks north of the Minas Geofracture (Figs. 1-1, 1-4 and 1-10, in pocket). This area is roughly coincident with the Fundy Basin (mobile rift) of Belt (1968).

In Nova Scotia it has not yet been determined if the potash was deposited in economic quantities. It is also unclear what factors were important in the localization of any deposits, i.e. in the deeper more rapidly subsiding basins and/or in paleogeographically remote basins which were physically or dynamically restricted.

Because these areas were within or close to the mobile area, they have undergone substantial deformation (Fig. 1-9). This structural complexity and scarcity of subsurface data make detailed paleogeographical-depositional modelling difficult to impossible. It is encouraging, however, that some areas, such as the Antigonish Basin, may not have been subjected to the intense evaporite flowage and deformation prevalent in other areas.

DISTRIBUTION OF SALT DEPOSITS AND OCCURRENCES

The five areas with known salt deposits (Figs. 1-4 and 1-10, in pocket) in Nova Scotia are the Hants-Colchester, Cumberland, Antigonish-Mabou, Canso-Bras d'Or and Sydney areas. In addition, four areas underlain by Windsor Group rocks may contain salt deposits, but this has not been established by drilling. These are the Mahone Bay, Pictou, Cheticamp-Margaree and Cape North areas. Thick salt deposits are found in most areas underlain by Windsor Group rocks (Figs. 1-1 and 1-5). In many of these areas, the Windsor Group rocks are overlain by a very thick sequence of Late Carboniferous rocks.

Within the five areas where salt is known to occur, 13 occurrences and 20 deposits are recognized (Fig. 1-10, in pocket and Table 1-2). Table 1-2 lists, groups, and classifies each deposit and occurrence, and assesses its potential for both salt and potash exploration. The exploration potential is based only on the limited area of the deposit or occurrence. Areas without salt defined by drilling may have significant potential, but cannot be objectively evaluated without more data.

The deposits and occurrences are sometimes defined in only a single drillhole and, as such, are inadequately known. The designation of deposit or occurrence is purely arbitrary and is based upon the quantity of salt actually intersected in drilling coupled with the quantity which may reasonably be present by comparison with similar structural and geological conditions in other better defined deposits and from gravity data where available. The deposits and occurrences were assessed only on their geological merits, with the quality of the salt, mining factors and depth to salt etc., not considered. The data related to these factors, with the exception of the depth, are generally unknown and highly variable, and therefore of limited value. The assignment of the deposit or occurrence rank is subject to further modification as the factors related to exploitability are studied in more detail and become better understood.

Between 1978 and 1980, five new deposits were defined by Noranda Exploration Company Ltd. and Chevron Standard Ltd., while they were conducting potash exploration in the Canso-Bras d'Or area. Two of these deposits, Orangedale and Malagwatch, contain associated potash. The others, Cleveland, Estmere, and St. Patricks, are defined by only one drillhole. Data on these deposits only became available following preparation of this report and will not be described here in detail.

Table 1-2. Nova Scotia salt deposits and occurrences

	Deposit or Occurrence	**Structural Type**	**Major Cycle(s)**	**Potential for Salt Exploration**	**Potential for Potash Exploration**
Hants-Colchester Area					
Beaver Brook	Deposit	B	1	good	poor-fair
Clarksville	Occurrence	B-C	5	fair	fair-good
Falmouth	Occurrence	?	1	poor	poor
Kennetcook	Occurrence	B-C	1	poor	poor
Shubenacadie-Stewiacke	Deposit	A	1,2,5	very good	poor
Stanley	Occurrence	B-C	1	fair	poor
Summerville	Occurrence	Vein	-	very poor	very poor
Upper Walton River	Occurrence	C	1-2?	poor-fair	poor-fair
Walton	Occurrence	B-C	1-2?	poor-fair	poor-fair
Cumberland Area					
Beckwith	Occurrence	C-D	?	fair	good
Malagash*	Deposit	D	?	fair	good
Nappan*	Deposit	D	?	fair	poor
Oxford*	Deposit	D	?	fair	fair-good
Pugwash*	Deposit	D	?	very good	good
Roslin	Occurrence	D	?	fair	fair
Antigonish-Mabou Area					
Antigonish	Deposit	B-C	1	fair	fair
James River*	Deposit	B-C	1	fair-good	fair-good
Mabou	Deposit	C-D	1-4?	fair-good	fair-good
Ohio	Occurrence	A	1	poor-fair	poor-fair
Pomquet River	Occurrence	C	1?	poor	poor
Southside Harbour*	Deposit	B	1	good	fair
Canso-Bras d'Or Area					
Cleveland*	Deposit	B-C	2-5?	fair	fair
Estmere	Deposit	B-C	2-5?	fair	fair
Kingsville	Deposit	C-D	1-5?	very good	fair-good
McIntyre Lake*	Deposit	C	1-5?	very good	good
Malagawatch*	Deposit	C?	1-4	good	good
Orangedale*	Deposit	C?	1-4	good	good
Port Richmond*	Deposit	C-D?	1-4	very good	fair
Seaview	Occurrence	C	1?	fair	fair
St. Patricks Channel	Deposit	C	1-4	fair-poor	fair-poor
St. Peters*	Deposit	C	1?	fair	fair
Sydney Area					
Boularderie	Deposit	A-B	1-2	good	good
East Bay	Occurrence	A	1?	fair	poor

*Potash salts reported.

CHAPTER 2
HANTS-COLCHESTER AREA

INTRODUCTION

Seven salt occurrences and two salt deposits are found in the Hants-Colchester area (Fig. 1-4). Several of the occurrences could be upgraded to deposits with further drilling. Each deposit and occurrence is described in alphabetical order: Beaver Brook, Clarksville, Falmouth, Kennetcook, Shubenacadie-Stewiacke, Stanley, Summerville, Upper Walton River, and Walton.

The two salt deposits recognized in the Hants-Colchester area are the Beaver Brook deposit and the Shubenacadie-Stewiacke deposit. The Beaver Brook deposit has only a single deep drillhole into salt, so is less well defined than the Shubenacadie-Stewiacke deposit, but still has good potential for further salt exploration. The gravity survey data and geological maps of the Beaver Brook area indicate a large salt mass, although the purity and extent remains to be proven. The Shubenacadie-Stewiacke deposit described by Boehner (1980a), is defined by a total of 20 drillholes into salt; five of these are deep penetrating. The deposit has a large lateral extent (potentially up to 40 km long by 5 km wide and up to 300 m thick) and appears to be a relatively undisturbed, gently folded stratified deposit (Type A). Preliminary analytical results from two deep drillholes, 9.3 km apart and sampled over salt thicknesses of 315 m and 272 m, show average grades of over 90% through intervals exceeding 30 m. Higher grades of up to 95% are found in thinner intervals. The low degree of deformation and the stratified nature together with the substantial thickness of the salt make the deposit geologically suitable for both mining and underground storage.

GENERAL WINDSOR GROUP STRATIGRAPHY

PREVIOUS WORK

The stratigraphy of the Carboniferous succession in the Hants-Colchester area has been studied by many workers since the early to mid-1800's. A detailed understanding was not achieved until Bell (1929) described the litho- and biostratigraphic subdivision of the lower part (Mississippian) of the Carboniferous. More recently the stratigraphy and structure of the Windsor Group (Fig. 2-1) has been intensively studied by R. G. Moore (1967) of Acadia University, and by the Nova Scotia Department of Mines and Energy (Giles, 1977; Giles and Ryan, 1976; Boehner, 1977b; Moore and Ryan, 1976; Giles and Boehner, 1979 and 1982a). Geological mapping by the Geological Survey of Canada in this area is covered on map sheets by Weeks (1948), Stevenson (1958, 1959), Crosby (1962), Boyle (1963, 1972), Benson (1967) and Taylor (1969). In addition, the area is covered by geological mapping completed by Faribault and Fletcher in the late 1800's and early 1900's.

PRE-WINDSOR GROUP STRATA

The Carboniferous succession underlies a large portion of the Hants-Colchester area occurring for the most part in the low lying valley areas. This area includes the major portion of the Minas Sub-basin of Bell (1958). The surrounding areas of higher elevations are generally underlain by greenschist metamorphosed shales and sandstones of the Cambro-Ordovician Meguma Group and Devonian-Early Carboniferous granitic intrusives.

The Carboniferous succession comprises both marine and continental sediments. The initial sedimentation of the Early Carboniferous is represented by the Horton Group which consists of continental fluvio-lacustrine siliciclastic sediments deposited with angular unconformity upon the metamorphic and intrusive basement. In the type Horton-Windsor area Bell (1929) recognized the following two Formations; a lower, Horton Bluff Formation, comprising dark grey arenaceous and argillaceous shales, grey feldspathic sandstones and grits, and an upper Cheverie Formation, consisting of grey arkose and red shale. Thickness in the type area was estimated by Bell (1929) to be 300-1000 m.

In the Shubenacadie area, Stevenson (1959) estimated a maximum thickness of 900 m. A deep oil well, Soquip et al., Noel No. 1, drilled near Kennetcook, intersected approximately 900 m of Horton Group rocks. This is comparable to thicknesses estimated by Bell (1929) and by Stevenson (1959). The southern limits of Carboniferous outcrop in the Shubenacadie area are marked by a thinning and coarsening trend and an eventual pinch-out of the Horton Group sediments in the Musquodoboit Valley. Horton Group rocks are reported to occur very sparingly in the Musquodoboit Valley area (Boehner, 1977b). This area is interpreted to be near the margins of the Horton Group depocentre and an area of Windsor Group onlap onto pre-Carboniferous basement. Bell's (1929) subdivisions in the type area have not been extended with certainty to the remainder of the Minas Sub-basin or to other outcrop areas in Nova Scotia.

DEFINITION OF THE WINDSOR GROUP

The Windsor Group Group was originally defined by Bell (1929, 1958). It consists of interstratified red-maroon siltstones, limestones, gypsum, salt, and anhydrite. Bell (1929) estimated a minimum total thickness of 472 m in the type area at Windsor.

The Windsor Group in the area was biostratigraphically subdivided by Bell (1929) into two major faunal zones and five subzones based mainly upon their contained Brachiopoda, Cephalopoda and Cnidaria. The Lower Windsor zone of Composita dawsoni was subdivided into Subzone A, the basal limestone (characterized by a paucity of megafauna), and Subzone B, characterized by Diodoceras avonensis . Bell subdivided the Upper Windsor zone of Martinia galataea into Subzone C, characterized by Dibunophyllum lambii and Nodosinella (Paleocrisidia) priscilla; Subzone D, characterized by Productus (Ovatia) semicubiculus; and Subzone E, characterized by Caninia dawsoni and Chonetes politus (Tournquistia polita). The names and ranges of these forms and others have been modified by Moore and Ryan (1976).

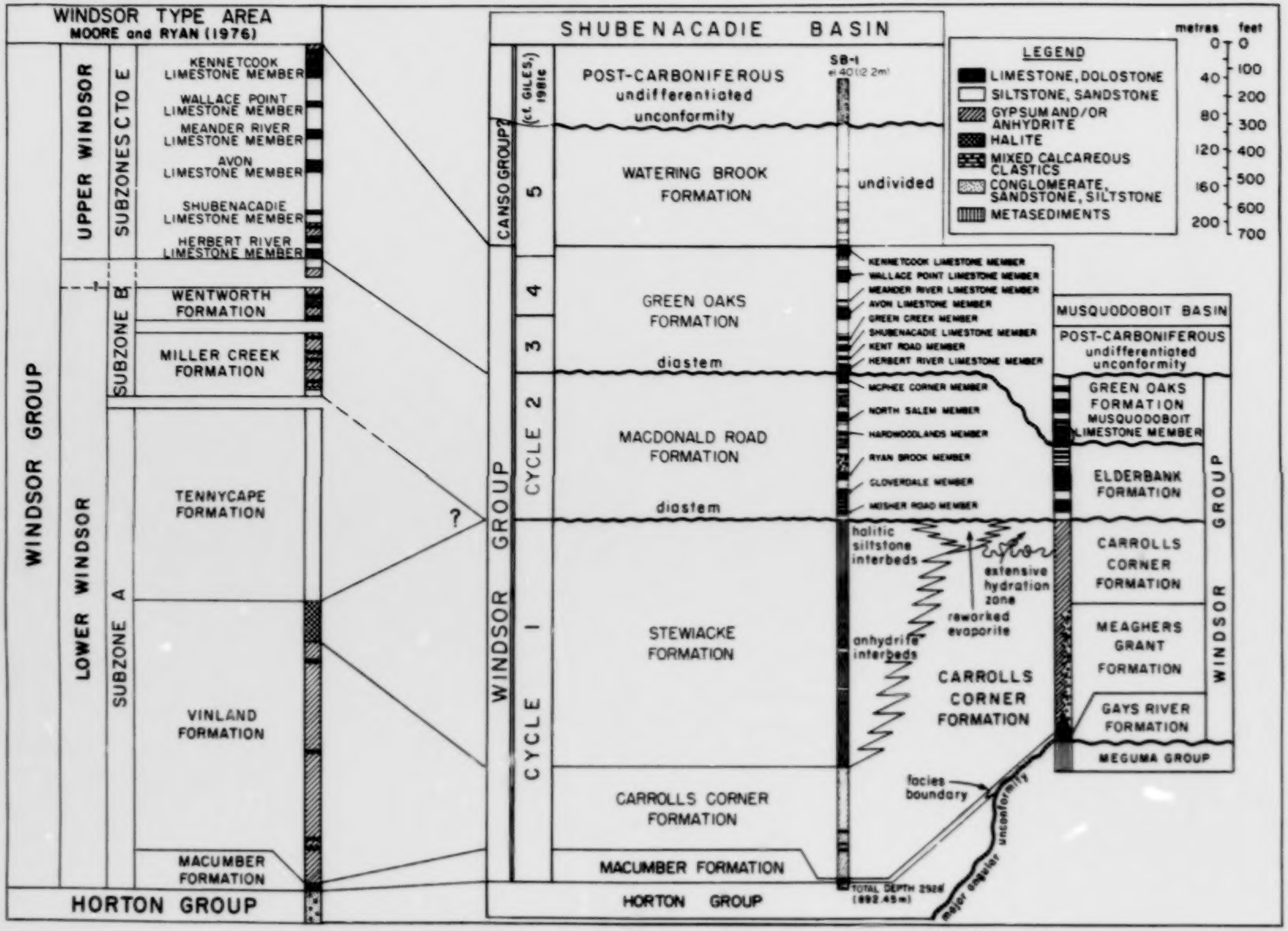

WINDSOR TYPE AREA
MOORE and RYAN (1976)
WINDSOR GROUP
UPPER WINDSOR
LOWER WINDSOR
SUBZONES C TO E
SUBZONE B
SUBZONE A
KENNETCOOK LIMESTONE MEMBER
WALLACE POINT LIMESTONE MEMBER
MEANDER RIVER LIMESTONE MEMBER
AVON LIMESTONE MEMBER
SHUBENACADIE LIMESTONE MEMBER
HERBERT RIVER LIMESTONE MEMBER
WENTWORTH FORMATION
MILLER CREEK FORMATION
TENNYCAPE FORMATION
VINLAND FORMATION
MACUMBER FORMATION
HORTON GROUP
?
SHUBENACADIE BASIN
CANSO GROUP?
WINDSOR GROUP
(cf. GILES, 1981c)
5
4
3
CYCLE 2
CYCLE 1
POST-CARBONIFEROUS undifferentiated
unconformity
WATERING BROOK FORMATION
GREEN OAKS FORMATION
diastem
MACDONALD ROAD FORMATION
diastem
STEWIACKE FORMATION
CARROLLS CORNER FORMATION
MACUMBER FORMATION
HORTON GROUP
SB-1
el 40 (12.2m)
undivided
KENNETCOOK LIMESTONE MEMBER
WALLACE POINT LIMESTONE MEMBER
MEANDER RIVER LIMESTONE MEMBER
AVON LIMESTONE MEMBER
GREEN CREEK MEMBER
SHUBENACADIE LIMESTONE MEMBER
KENT ROAD MEMBER
HERBERT RIVER LIMESTONE MEMBER
MCPHEE CORNER MEMBER
NORTH SALEM MEMBER
HARDWOODLANDS MEMBER
RYAN BROOK MEMBER
CLOVERDALE MEMBER
MOSHER ROAD MEMBER
halitic siltstone interbeds
extensive hydration zone
reworked evaporite
anhydrite interbeds
CARROLLS CORNER FORMATION
facies boundary
major angular unconformity
TOTAL DEPTH 2928' (892.45m)
LEGEND
LIMESTONE, DOLOSTONE
SILTSTONE, SANDSTONE
GYPSUM AND/OR ANHYDRITE
HALITE
MIXED CALCAREOUS CLASTICS
CONGLOMERATE, SANDSTONE, SILTSTONE
METASEDIMENTS
metres
feet
0
40
80
120
160
200
0
100
200
300
400
500
600
700
MUSQUODOBOIT BASIN
POST-CARBONIFEROUS undifferentiated
unconformity
GREEN OAKS FORMATION
MUSQUODOBOIT LIMESTONE MEMBER
ELDERBANK FORMATION
CARROLLS CORNER FORMATION
MEAGHERS GRANT FORMATION
GAYS RIVER FORMATION
MEGUMA GROUP
WINDSOR GROUP

Figure 2-1. Windsor Group stratigraphy and correlation, Hants-Colchester area.

The base of the Windsor Group (Bell, 1929) is marked by a thin laminated basal limestone. Bell (1929) also included an underlying calcareous grey quartzite and limestone conglomerate unit as part of the Windsor Group. In the type area the basal limestone is approximately 4 m thick. The underlying quartzite unit, locally bearing Schizodus cheverensis on its upper surface, is 6.7 m thick and conformably overlies the Cheverie Formation of the Horton Group. Near the type area, the basal limestone is called the Macumber Formation (Weeks, 1948). In other areas it is called A_1 limestone (Sage, 1954), Ribbon Limestone, etc. It is usually overlain by a thick section of gypsum and/or anhydrite.

More recent work in the southeastern extremity of the Shubenacadie-Stewiacke Valley and Musquodoboit Valley (Giles and Boehner, 1979) indicated that the basal A Subzone limestone was deposited upon pre-Carboniferous basement rocks (overstepping the Horton pinch-out), and locally developed a varied flora and fauna. In banks it reaches thicknesses of over 45 m (Gays River Formation, Giles et al., 1979). The thick anhydrite of the overlying Carrolls Corner Formation (Giles, 1977) is also called Subzone A gypsum (Bell, 1929), Lower Sulphate (Weeks, 1948), and part of the Vinland Formation (Moore and Ryan, 1976). This unit intertongues with, and is laterally equivalent to, the Meaghers Grant Formation (Boehner, 1977b), a near shore marine fluvial-deltaic complex in the Musquodoboit Valley. The Stewiacke Formation (Giles, 1977), a thick (up to 300 m) salt unit encountered in the Shubenacadie-Stewiacke Valley, overlies and, in part, may be a lateral equivalent of the Carrolls Corner Formation. These two units have a combined minimum thickness of 400 m. The salt occupies a similar position in the Windsor area (Moore and Ryan, 1976) and is the most important salt unit in the Hants-Colchester area.

An unknown thickness of soft maroon-red shales overlying the Lower Sulphate (Weeks, 1948) is present in the northern part of Hants County. The unit was named the Tennycape Formation by Weeks (1948). A minimum thickness of 183 m was estimated by Weeks (1948). The exact stratigraphy and areal extent of this facies is not well defined. The unit is probably well represented in drilling in the northern and central parts of the Kennetcook Valley where thick sequences of red shales with rare, thin limestone are present. Its relationship to younger strata is not certain, although Weeks (1948) indicated the possible existence of a second or upper sulphate unit overlying the Tennycape Formation. This upper unit could be part of the cyclic B Subzone succession or, as Weeks (1948) suggested, a thrust sheet of the Lower Sulphate. The Tennycape Formation, in any case, is a wedge or tongue shaped unit that is apparently not present in the Shubenacadie area (Fig. 2-1).

In most areas, the thick A Subzone sulphate-halite units are overlain by the B Subzone cyclic sequence consisting of interstratified fossiliferous marine carbonates, siltstones, and evaporites including thin halite beds. In the Windsor area, this section can be subdivided into two parts, according to Moore and Ryan (1976): a lower, Miller Creek Formation in which evaporite is predominant; and an upper, Wentworth Formation in which siltstone becomes more abundant. These units have undergone complex nappe-like recumbent folding (Geldsetzer et al., 1980), probably caused by gravity sliding upon the A Subzone evaporites which acted as décollement surface (Keppie, 1977).

In the Shubenacadie-Stewiacke Valley area, a comparable cyclic succession called the MacDonald Road Formation (Giles, 1977; Giles and Boehner, 1979) is recognized. It contains thin, lensoidal shaped salt beds locally. The sequence has a total thickness of approximately 170 m. In this area the MacDonald Road Formation is overlain with possible slight disconformity (Giles, 1978) by a sequence of alternating fossiliferous marine carbonates, red siltstone and locally gypsum and anhydrite (in a saline facies) called the Green Oaks Formation (Giles, 1977; Giles and Boehner, 1979).

The lithostratigraphy of the upper Windsor carbonate units was described by Moore (1967) and can be readily correlated throughout the Hants-Colchester area as laterally extensive transgressive-regressive marine carbonate sheets. The thickness of this interval ranges from 137 m in the Shubenacadie-Stewiacke Valley to over 730 m in the incomplete composite section, of the Green Creek area (Moore, 1967). Moore (1967) also indicated a thickness of approximately 240 m in the Herbert River and Meander River areas near Windsor.

Moore (1967), on the basis of isopach and other data, concluded the Minas Sub-basin (Bell, 1958) represented a U-shaped trough opening to the northeast. Howie (1979) and Giles (1981b) indicated a seaway area to the south of the Minas Sub-basin opening through the Nova Scotia platform.

In the Shubenacadie-Stewiacke Valley the uppermost unit of the Windsor Group is the Kennetcook Limestone Member, which is overlain by a succession of interstratified grey green siltstone, gypsum and anhydrite and locally halite. The succession is apparently conformable with, and lithologically similar to, the saline facies of the Green Oaks Formation except for the absence of marine carbonate units. The succession is in excess of 200 m thick and is believed to be overlain by younger rocks including buff sandstone and maroon shale. These rocks are lithologically similar to a sequence described in the Windsor area as the Scotch Village Formation of Riversdale Group age (Stevenson, 1959). Howie and Barss (1975), however, indicated that these rocks are probably of Pictou age based on their spore assemblage. The nature of the contact between this sequence and the underlying section is not known, although the apparent age gap suggests a major unconformity. In the Windsor area and western Kennetcook map-area, the Scotch Village Formation generally has flat lying bedding and a wide distribution. The maroon shale is common in several drillholes in the Walton and Kennetcook areas in the central part of the Shubenacadie-Stewiacke Valley. The relationship between these rocks and the apparently older maroon-red shales of the Tennycape Formation is uncertain. Complex structure, including extensive faulting (Boyle, 1963) and folding (gravity sliding), makes assessment difficult. Red terrigenous clastic sediment is the dominant rock type, making it extremely difficult to determine the stratigraphic position of those sediments overlying the salt and basal anhydrite. This part of the Hants-Colchester area (northwestern Minas Sub-basin) is the least understood stratigraphically and is probably the most disturbed structurally.

STRUCTURAL ZONATION

The Windsor Group rocks in the Hants-Colchester area occur in a series of variably faulted generally northeasterly trending anticlines and synclines locally overturned and recumbently folded. Giles (1977) described a trend toward increasing structural complexity ranging from relatively undeformed gently folded rocks in the Musquodoboit Valley on the southeast through to severely deformed toward the northwest in the Windsor and Kennetcook areas (Fig. 2-2). This structural zonation and the sediment thickening trend in the same direction is suggested by Giles to be due to increased tectonic mobility, both during and after deposition. The regional structural trend is important in controlling the location, limits and structural configuration of the salt deposits in the area.

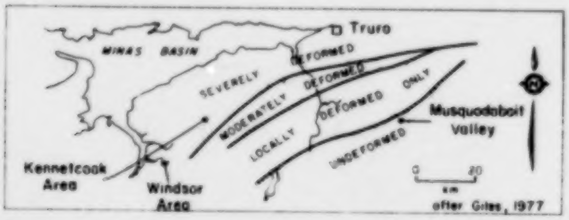


Figure 2-2. Structural zonation of the Windsor Group in the Hants-Colchester area.

BEAVER BROOK DEPOSIT

LOCATION

The Beaver Brook deposit is located approximately 14 km southwest of Truro and 11 km west of Hilden (NTS 11E/06W) in Colchester County (Figs. 1-4, 1-10 and 2-3). The area is bordered on the west by the Shubenacadie River and 6 km to the north by the Cobequid Bay.

The area is readily accessible by paved and gravel roads from the Trans-Canada Highway 104 between Truro and Halifax. The terrain in the vicinity is moderately undulating with hills rarely exceeding 120 m.

HISTORICAL BACKGROUND

The Beaver Brook area, mapped by Stevenson (1958), is part of the "Shubenacadie Basin" that was originally investigated for its potash potential by Wright (1931). The scarcity of outcrop and a lack of salt springs combined with the short duration of the investigation resulted in the area being assessed as unpromising for potash exploration.

In 1956 drilling for gypsum in the Hilden area 6.5 km to the east encountered native sulphur veinlets at shallow depths. In 1966 the Nova Scotia Department of Mines drilled a deeper exploration hole in the vicinity of the 1956 drilling. The results of this drilling prompted New Senator-Rouyn and Peel-Elder Consortium to further exploration and drilling. A gravity survey by the Nova Scotia Research Foundation for New Senator-Rouyn and Peel-Elder delineated a large,elongated Bouguer gravity low centred near Beaver Brook, approximately 6.5 km southwest of the initial drilling. This low was believed to have been related to salt and was drilled in 1968.

GEOLOGY

The precise geology of the Beaver Brook deposit is not readily determined, since it is located in an area with very little outcrop and only one drillhole into salt (Figs. 2-3, 2-4 and 2-5). The deposit probably occurs in the lower part of the Windsor Group as mapped by Stevenson (1958) and substantiated by the stratigraphic succession found in the defining drillholes (NSDM 4735 and SD-1). The Windsor Group in the area is probably moderately to severely deformed. Detailed mapping in the area indicates a trend toward increasing structural complexity to the north (Fig. 2-2), making detailed interpretation of the structural configuration of the deposit difficult. The gravity survey by the Nova Scotia Research Foundation outlined a large Bouguer gravity low striking slightly southeast, extending from Princeport (Fig. 2-3) on the Shubenacadie River 13 km toward Brookfield, with the minimum located approximately midway between Beaver Brook and Green Oaks (Fig. 2-3).

New Senator-Rouyn and Peel-Elder drilled a test hole BB-1(SD-1) (Fig. 2-5) at the western end of the minimum to a depth of 428 m (1404 ft.), where the hole was lost. Rock salt was reached at 401.4 m (1317 ft.) and was not completely penetrated at 428 m (1404 ft.). The upper part of the hole consists of alternating red and green clastics, fossiliferous limestone and dolostone, and gypsum and anhydrite. This type of cyclic sequence is typical of the B Subzone of the lower Windsor. Bedding dips in the core range from 10° to 45° down through the section. NSDM 4735 (SD-2, BB-2), a redrill of BB-1 (SD-1), was drilled 28.3 m south of SD-1. The first 305 m (100 ft.) were triconed and the upper salt was intersected at 392 m (1286 ft.) and ended at 411.5 m (1350 ft.). A mixed section of mudstone and salt was intersected between 411.5 and 630.3 m (1350-2068 ft.). Bedding dips in this section are very steep ranging between 60° and 80°. At 630.3 m (2068 ft.) the lower (main) salt mass was penetrated, but was not completely intersected at 733.3 m (2406 ft.) (core depth) where the hole was stopped. Poorly defined bedding dips of 60-75° are described in some intervals. No potash minerals are reported although a few small traces of sulphur were described.

The major structure is probably an east-west trending salt cored anticline that generally follows the Bouguer gravity low (Fig. 2-3). This structural trend is at an angle to and is probably separated by a fault from a synclinal structure to the south. The northern contact of the Windsor Group with the Horton Group was indicated to be concordant by Stevenson (1958) although drill exploration by New Senator et al. indicated the contact is faulted and highly disturbed and may involve reverse or thrust faulting, at least on a local scale. The interpreted structural configuation portrayed in Figure 2-5 is based upon very limited data.

GEOCHEMISTRY

The salt intervals in the NSDM 4735 (SD-2) hole were analyzed by the Nova Scotia Research Foundation. The sampling method involved taking two to three inch whole core samples at five foot intervals through the salt zones. The salt grades and intervals from Nova Scotia Department of Mines and Energy, Assessment File 11E/6B 60-D-26(03) are summarized in Table 2-1 and detailed analyses are tabulated in Appendix B.

The bromine content of the halite indicates brine concentrations were probably low and did not reach potash salt deposition.

Table 2-1. Chemical analyses, NSDM 4735 (SD-2)*

Interval (feet) Representative of	NaCl (per cent) Average of Individual Samples		Soluble NaCl (per cent) Whole Rock Composite Samples
	Whole Rock	Soluble	
Lower Salt			
2067.8-2102.5	93.94	95.57	97.99
2102.5-2162.5	68.64	84.09	88.04
2162.5-2187.5	92.74	94.44	96.41
2187.5-2262.5	56.16	81.35	83.07
2262.5-2322.5	94.06	97.79	94.89
2322.5-2404	82.50	87.26	87.36
Upper Salt			
1286 -1327.5	78.74	89.30	91.68
1327.5-1350	92.51	97.29	92.62

*Nova Scotia Department of Mines, 1968c.

ECONOMIC CONSIDERATIONS

Depth to the lower (main) salt of 630.3 m (2068 ft.) is defined in only one hole, NSDM 4735 (BB-2, SD-2), which did not completely penetrate the lower salt when the hole was abandoned at 733.3 m (2406 ft.). The depth to the upper salt (35 m thick) is 392 m (1286 ft.). Average grade of the deposit is 68.38% NaCl in whole rock and 89.63% in soluble NaCl. Potash was not identified at this location. The size of the deposit as outlined by the Bouguer gravity survey is approximately 5 km by 1 km. Thickness probably exceeds 300 m and possibly could be up to 450 m.

Because salt springs were not reported in the area, the salt body is probably well sealed from circulating groundwater and subsurface solution.

The deposit is located close to highway transportation and is within easy reach of any tidal power developments in the eastern part of the Minas Basin. The deposit is deep enough for underground storage development and may be suitable for economic, conventional underground mining extraction of salt. The deposit is considered to have good potential for further exploration and possible development.

CLARKSVILLE OCCURRENCE

LOCATION

The Clarksville occurrence is located 1.5 km north of Clarksville (NTS 11E/04W), Hants County (Figs. 1-4, 1-10 and 2-6). Clarksville is 26 km northeast of Windsor and is located near the southern border of the Kennetcook River valley. The area is readily accessible by paved and gravel highways that parallel the Kennetcook River. The terrain to the north of the occurrence is typical of the Carboniferous Lowlands with very gently undulating hills and maximum elevations rarely exceeding 60 m. The area to the south is dominated by the Rawdon Hills Highlands where elevations locally reach up to 200 m.

HISTORICAL BACKGROUND

The abundance of salt springs in the "Windsor Basin Area" (Hayes, 1931) initially brought attention to the possible occurrence of exploitable salt and potash. Twelve salt springs were investigated, although none are reported from the immediate vicinity of the Clarksville occurrence. This location was mapped by Stevenson (1959) as part of the Kennetcook map sheet.

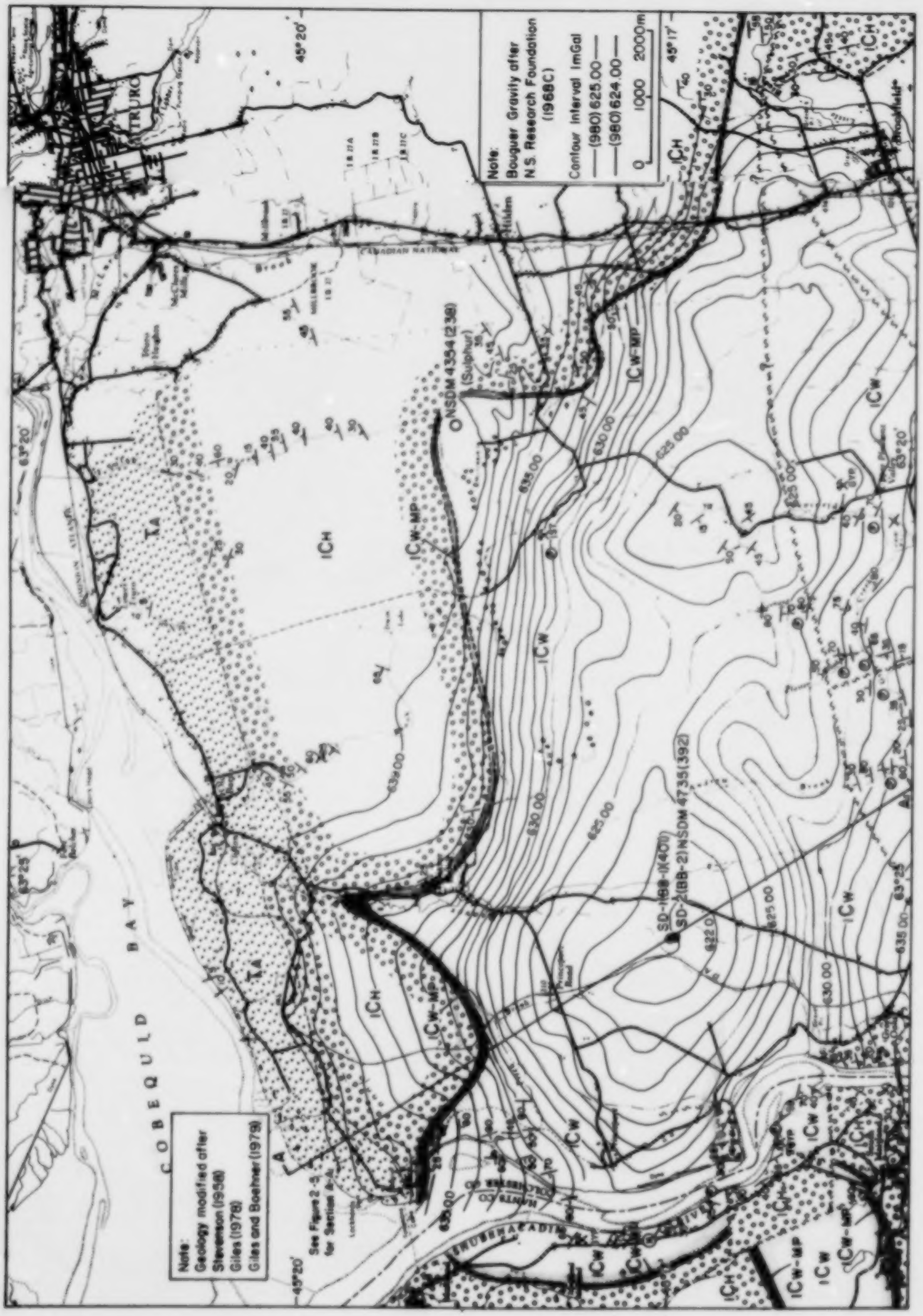

Note:
Geology modified after
Stevenson (1958)
Giles (1978)
Giles and Boehner (1979)
See Figure 2-5 for Section A-A
Note:
Bouguer Gravity after
N.S. Research Foundation
(1968C)
Contour interval 1mGal
—(980) 625.00—
—(980) 624.00—
0 1000 2000m
COBEQUID BAY
TRURO
SHUBENACADIE RIVER
CANADIAN NATIONAL
45°20'
45°17'
63°20'
63°25'
TA
ICH
ICW
ICW-MP
NSDM 4354 (238) (Sulphur)
SD-1(BB-1)(401)
SD-2(BB-2) NSDM 4735 (392)
630.00
635.00
625.00
622.00
A
A'

Figure 2-3. Geological map and Bouguer gravity anomaly map, Beaver Brook deposit, Colchester County.

LEGEND

TRIASSIC

TrA *ANNAPOLIS FORMATION:* shale and sandstone

CARBONIFEROUS
UPPER CARBONIFEROUS

1CSV *SCOTCH VILLAGE FORMATION:* sandstone and shale

LOWER CARBONIFEROUS
WINDSOR GROUP

1CW Undivided siltstone, shale, anhydrite, gypsum, halite, and limestone

1CW-MP *MACUMBER AND PEMBROKE FORMATIONS:* limestone and limestone pebble conglomerate

HORTON GROUP

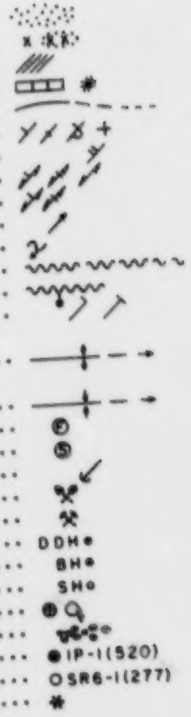
1CH Undivided sandstone, shale and conglomerate

ORDOVICIAN
MEGUMA GROUP

OM Undivided slate and metasandstone

SYMBOLS

Heavily drift-covered area
Rock outcrop, area of outcrop
Limestone or dolomite outcrop (Faribault-Fletcher maps)
Gypsum outcrop
Geological boundary (defined, approximate, assumed)
Bedding, tops known (inclined, vertical, overturned, horizontal)
Bedding, tops unknown (inclined)
Schistosity (inclined, vertical, dip unknown)
Gneissosity (inclined, vertical)
Plunge of minor fold
Drag fold (arrow indicates plunge)
Fault (defined, approximate, assumed)
Fault (solid circle indicates downthrow side)
Joint (inclined, vertical)
Anticline (defined, approximate, arrow indicates direction of plunge)
Syncline (defined, approximate, arrow indicates direction of plunge)
Fossil locality
Spore sample
Glacial striae (ice flow direction known)
Gravel deposit
Quarry
Diamond-drill hole
Borehole
Sinkhole
Salt spring
Observed karst topography
Drillhole intersecting salt; number (depth to salt, metres)
Drillhole without salt; number (Total depth, metres)
Drillhole location precise to 150 m



MINERALS

Anhydrite	ah	Limestone	lst
Gypsum	gyp	Pyrite	py
Lead	Pb	Zinc	Zn
Celestite	Sr		

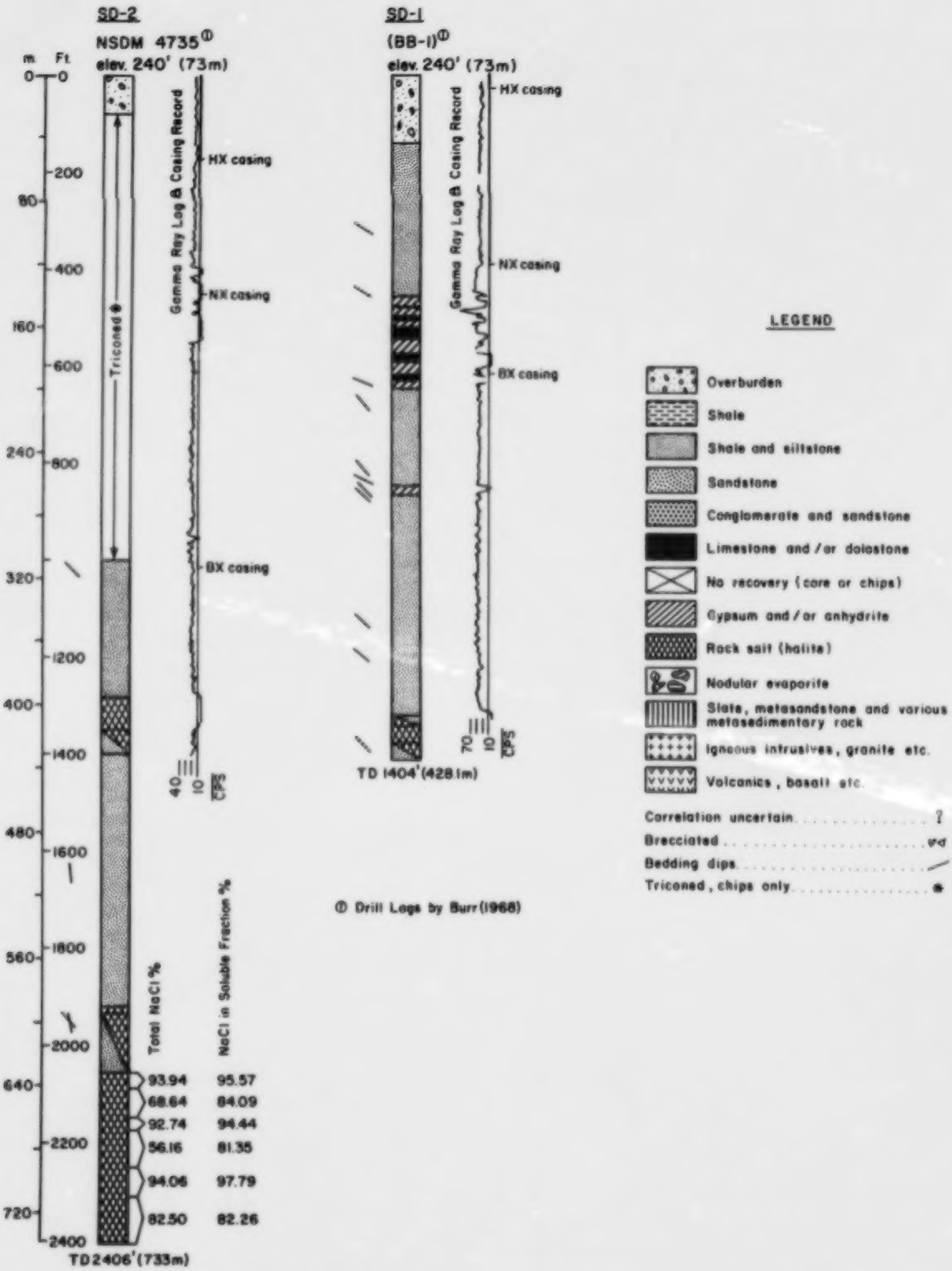

SD-2
NSDM 4735①
elev. 240' (73m)
m
Ft
0
80
160
240
320
400
480
560
640
720
200
400
600
800
1200
1400
1600
1800
2000
2200
2400
Triconed ✱
Gamma Ray Log & Casing Record
HX casing
NX casing
BX casing
40
10
CPS
Total NaCl %
NaCl in Soluble Fraction %
93.94
95.57
68.64
84.09
92.74
94.44
56.16
81.35
94.06
97.79
82.50
82.26
TD 2406'(733m)
SD-1
(BB-1)①
elev. 240' (73m)
HX casing
NX casing
BX casing
70
10
CPS
TD 1404'(428.1m)
① Drill Logs by Burr (1968)
LEGEND
Overburden
Shale
Shale and siltstone
Sandstone
Conglomerate and sandstone
Limestone and / or dolostone
No recovery (core or chips)
Gypsum and / or anhydrite
Rock salt (halite)
Nodular evaporite
Slate, metasandstone and various metasedimentary rock
Igneous intrusives, granite etc.
Volcanics, basalt etc.
Correlation uncertain ?
Brecciated
Bedding dips
Triconed, chips only ✱

Figure 2-4. Drillhole profiles, Beaver Brook deposit, Colchester County.

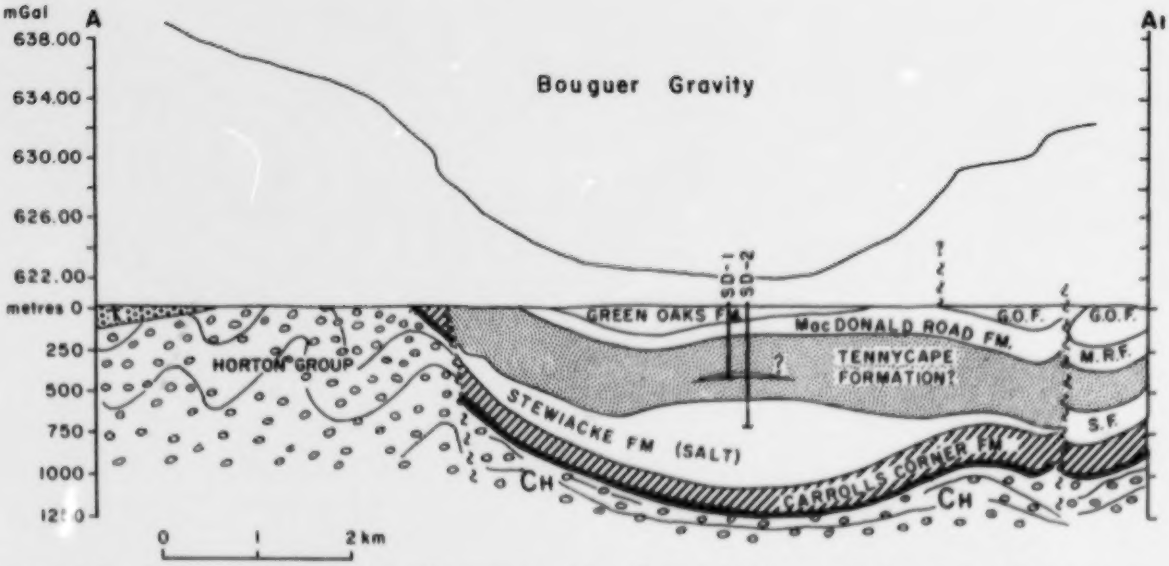


Figure 2-5. Geology and Bouguer gravity cross-section, Beaver Brook deposit (see Fig. 2-3 for location and legend).

In 1966 Scurry-Rainbow Oil Limited drilled an exploration hole for sulphur (SR6-1) approximately 1.5 km west of Clarksville on an elongate Bouguer gravity low. This hole was spudded in the Scotch Village Formation and was abandoned at 277 m (910 ft.). It penetrated a thick sequence of alternating red and grey shale and grey to red sandstone without intersecting salt.

In 1967 Dresser Minerals drilled WS-1 approximately 5 km north-northwest of HC-1. This hole penetrated Scotch Village Formation to a total depth of 171 m (560 ft.). A second hole WCR-1 was drilled approximately 7.5 km south-southwest of HC-1 near Centre Rawdon. This hole intersected alternating red mudstone, calcareous shale, and limestone. The hole was abandoned in anhydrite at a depth of 620 m (2034 ft.). Only two cores were cut in this hole; the first at 393.5-398 m (1291-1306 ft), in which dark shaly limestone was reported; and the second at 442.6-446.5 m (1452-1465 ft.), in which anhydrite breccia was reported.

In 1974, International Minerals and Chemical Corporation drilled an exploration hole for potash, approximately 1.5 km north of Clarksville (Fig. 2-7). This hole, HC-1, was abandoned at 371.2 m (1218 ft.) after penetrating brecciated and steeply dipping halite with anhydrite in the lower 90 m (true thickness of approximately 44 m). Potash was not intersected in the hole and no further drilling has been undertaken in this area. The area was further investigated for potash by Cominco Limited (1981). A drillhole was planned but was not completed.

GEOLOGY

The major rock units in the Clarksville area (Fig. 2-6) are the pre-Carboniferous metamorphic basement rocks belonging to the Meguma Group which form the Rawdon Hills Highlands to the south; the Lower Carboniferous Horton Group sandstones, conglomerate, and shale; and the marine Windsor Group. All units are steeply dipping and trend generally northeasterly except the Scotch Village Formation which is relatively flat lying. Outcrops of Windsor Group rocks are scarce, although karst topography, which indicates the presence of gypsum and anhydrite, is quite common. The bedding attitudes recorded from Windsor outcrops generally have northeasterly strikes and steep (55°) dips to the northwest.

A large 30 mGal Bouguer gravity low (Fig. 2-8) parallels the regional strike and extends from Stanley in the southwest to Kennetcook towards the northeast. The large faults, together with the steeply dipping beds, indicate the area is structurally complex.

The stratigraphy of the Windsor Group in the area is not specifically known, although the extensive development of karst topography indicates basal anhydrite of the Windsor Group is probable along the southern faulted contact. The upper part of the Windsor section is virtually unknown; however, several fossil localities are present indicating possible B Subzone and/or Upper Windsor strata. The Scurry-Rainbow borehole SR6-1 drilled 1.5 km west of Clarksville penetrated a thick section of red and grey shales and sandstones typical of the Scotch Village Formation. This hole probably never reached the underlying Windsor Group succession. The HC-1 drillhole (Fig. 2-7) in comparison penetrated a moderately dipping (bedding steepens with depth) sequence of red and grey shale and siltstone overlying a more steeply dipping sequence of anhydrite interbedded with grey shale which in turn overlies the anhydrite and salt. A similar

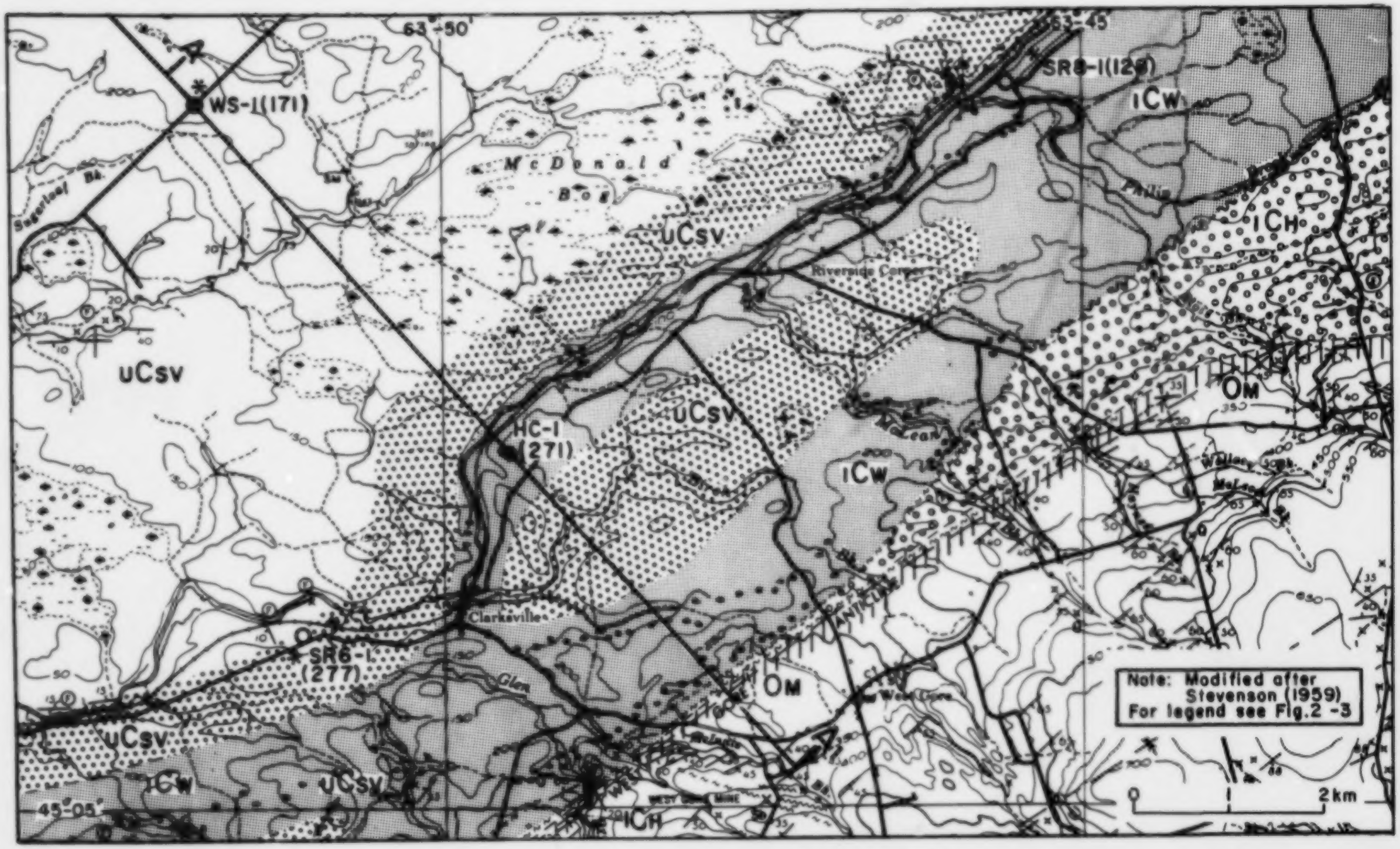
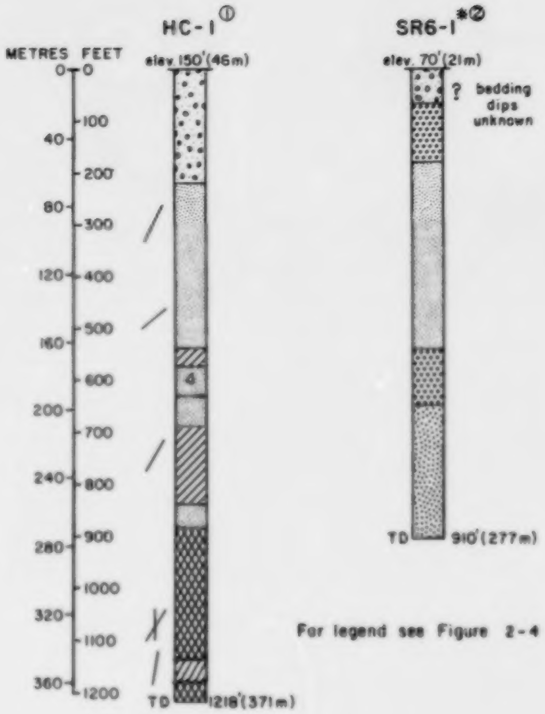

63°50'
63°45'
WS-1(171)
SR8-1(129)
lCw
McDonald Bog
uCsv
lCH
Riverside Corner
uCsv
OM
HC-1 (271)
uCsv
lCw
Clarkeville
SR6-1 (277)
OM
Glen
uCsv
lCw
uCsv
45°05'
lCH
Note: Modified after Stevenson (1959) For legend see Fig.2 -3
0
1
2km

Figure 2-6. Geology in the vicinity of the Clarkeville occurrence, Hants County, Nova Scotia.



Drill logs by: ① N.S. Dept of Mines, 1975
② Kawase, 1967

Figure 2-7. Drillhole profiles, Clarksville occurrence, Hants County. (For locations see Fig. 2-6)

sequence of units overlying the Kennetcook Limestone Member in the Shubenacadie area was assigned to the Watering Brook Formation (Giles and Boehner, 1979). It is probable that the entire HC-1 stratigraphic section is younger than the uppermost Windsor Kennetcook Limestone Member and that the salt, anhydrite and siltstone mudstone are part of the Watering Brook Formation (Fig. 2-1). Spore assemblages recovered from samples at depths of 143 m (469 ft.) and 156 m (511 ft.) were assigned by M. S. Barss (written communication, 1980) to Zone III of Utting (1980). This assignment supports the correlation of that part of HC-1 with the Watering Brook Formation. The size and magnitude (30 mGal) of the Bouguer gravity anomaly (Figs. 2-8 and 2-9) indicate a large mass of salt may be present, and if so, it probably is the thickened Lower Windsor main salt. The rocks overlying the salt in the HC-1 drillhole are highly fractured and locally have abundant veins of orangeish halite. This feature is often associated with tectonically disturbed Nova Scotia salt structures.

ECONOMIC CONSIDERATIONS

The Clarksville occurrence comprises halite with no potash reported. The salt is steeply dipping 45-80° and has interbeds of anhydrite. The salt was intersected at a depth of 271 m (889 ft.) and much of the core in the drillhole has been highly fractured and veined by reddish to orange halite. Approximately 87 m (285 ft.) (apparent thickness) were intersected with a probable true thickness of less than 44 m (144 ft.). The precise structural configuation and lateral extent of the salt mass has not been established. When these are better defined the occurrence may be upgraded to deposit status. No analyses are available on the salt in the HC-1 drillhole. The purity is believed to be 80-85% NaCl (visible estimate, whole rock), too low a grade for conventional underground mining. While this is not presently considered an economic deposit, there is good potential for further salt and potash exploration.

FALMOUTH OCCURRENCE

LOCATION

The Falmouth occurrence is located near the Village of Falmouth, 2 km west of Windsor (NTS 21A/16E) and approximately 10 km south of the port of Hantsport on the Avon River estuary, western Hants County (Figs. 1-4, 1-10 and 2-10).

The area is readily accessible by paved roads connected with the Trans-Canada Highway 101. The Windsor to Annapolis Valley line of the Dominion Atlantic Railway passes within 1.5 km of the occurrence.

This area is situated within the Carboniferous Lowlands characterized by gently undulating hills whose elevations rarely exceed 60 m. It is bordered to the west and south by the central Nova Scotia uplands with elevations from 150 m to over 230 m.

HISTORICAL BACKGROUND

The Falmouth occurrence was encountered during petroleum exploration by a private concern which drilled four boreholes between 1911 and 1922. The present knowledge of the occurrence is based on the assessment report by Wright (1931) obtained from an unpublished drilling report by A. E. Flinn. Falmouth Nos. 2 and 4 are reported to have penetrated a salt bed, and Falmouth No. 1 is reported to have produced a salt brine. Salt was not reported in Falmouth No. 3.

E. R. Faribault and H. Fletcher mapped the area in 1909. Bell (1929) published detailed geological maps for the immediate area of the occurrence. The general geology of the area was described by Bell (1929, 1958), who also defined the faunal zones and subzones, and the type section of the Windsor (Series) Group located at Windsor on the opposite shore of the Avon River. Taylor (1969) included part of the area on a regional compilation map.

GEOLOGY

The major rock units recognized in the area include the Meguma, Horton and Windsor Groups. The geology of the Windsor Group around Falmouth appears to have the configuration of a syncline or synclinorium with a faulted southern contact (Butler Mountain Fault, Bell, 1958). The rocks intersected in the Falmouth holes were probably

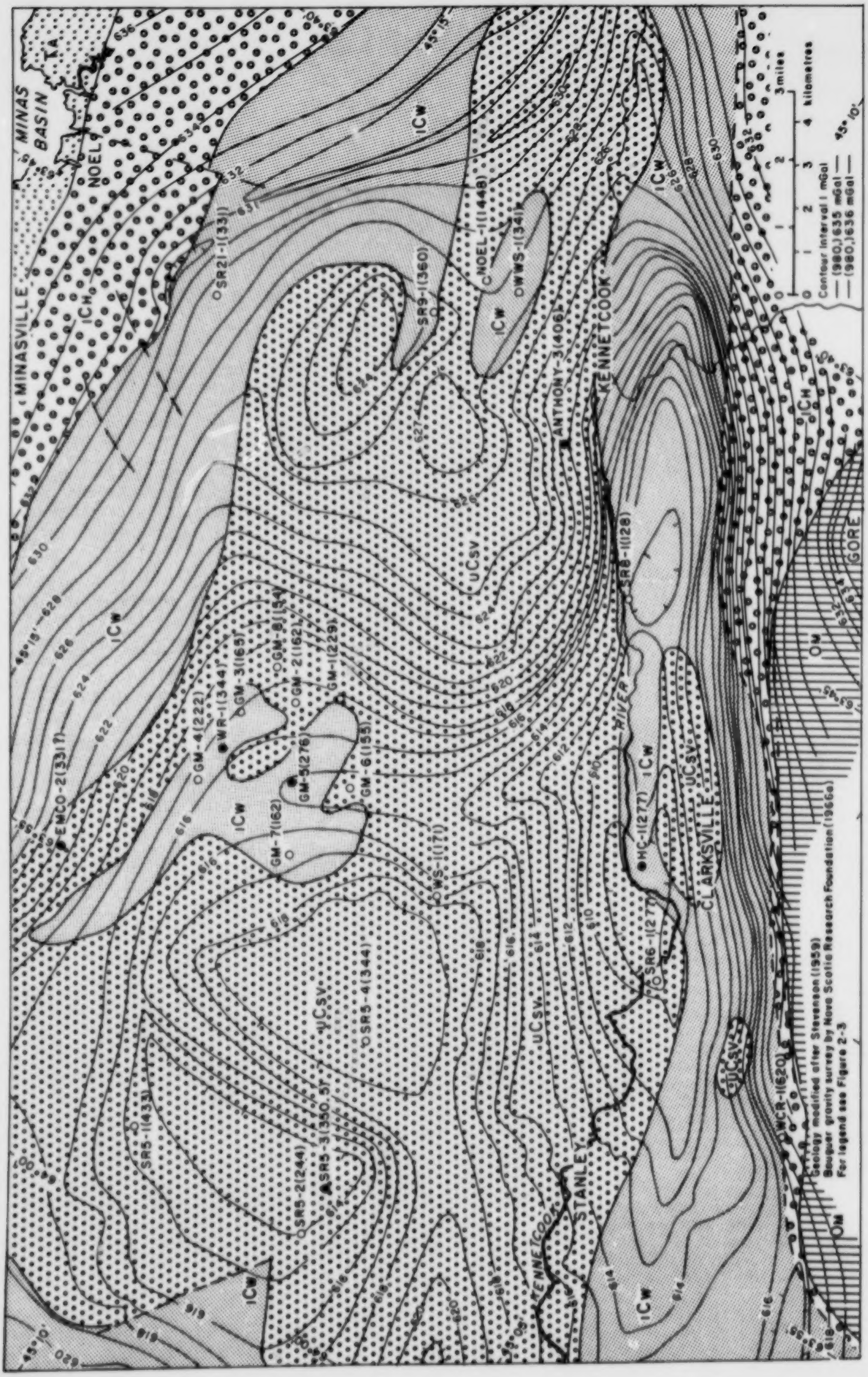

MINAS BASIN
NOEL
MINASVILLE
TA
lCH
lCw
uCsv
uCsw
Om
KENNETCOOK
STANLEY
CLARKSVILLE
KENNETCOOK RIVER
GORE
EMCO-2(3317)
SR21-1(3311)
SR9-1(360)
NOEL-1(1448)
WWS-1(341)
ANTHONY-3(406)
RB-1(128)
GM-4(222)
WR-1(344)
GM-3(165)
GM-8(154)
GM-2(162)
GM-1(229)
GM-5(276)
GM-6(155)
GM-7(162)
WS-1(171)
MC-1(277)
SR6-1(277)
SR5-4(344)
SR5-1(433)
SR5-3(350.5)
SR5-2(244)
WCR-1(620)
45°15'
45°10'
45°05'
0 1 2 3 miles
0 1 2 3 4 kilometres
Contour interval 1 mGal
(980,)635 mGal
(980,)636 mGal
Geology modified after Stevenson (1959)
Bouguer gravity survey by Nova Scotia Research Foundation (1966a)
For legend see Figure 2-3

Figure 2-8. Bouguer gravity anomaly map in the vicinity of the Clarksville, Kennetcook, Stanley, and Upper Walton River occurrences.

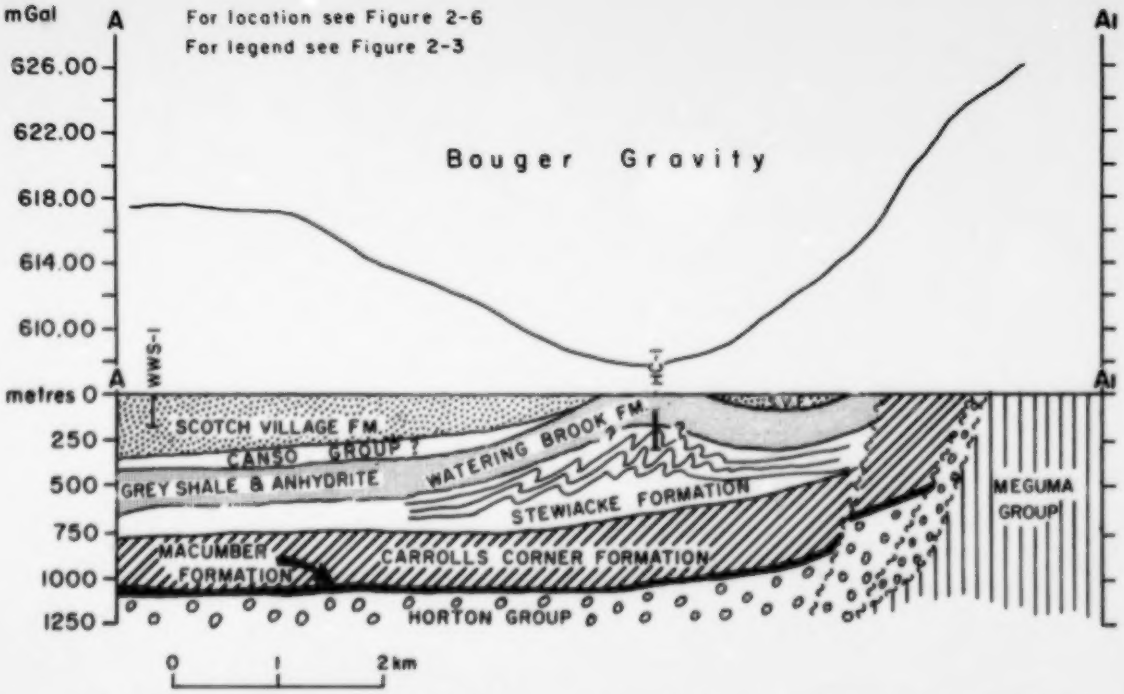

mGal
A
A1
For location see Figure 2-6
For legend see Figure 2-3
626.00
622.00
618.00
614.00
610.00
Bouger Gravity
WWS-1
HC-1
metres 0
250
500
750
1000
1250
SCOTCH VILLAGE FM.
CANSO GROUP ?
GREY SHALE & ANHYDRITE
WATERING BROOK FM.
STEWIACKE FORMATION
MACUMBER FORMATION
CARROLLS CORNER FORMATION
HORTON GROUP
MEGUMA GROUP
0
1
2km

Figure 2-9. Bouguer gravity and geological cross-section, Clarksville occurrence, Hants County.

part of the Lower Windsor A Subzone basal anhydrite (Vinland Formation) (Fig. 2-11). Falmouth Station No. 1 was drilled in 1912 and is reported by Bell (1958) to have penetrated 366 m (1200 ft.) of gypsum before reaching the underlying Horton sandstones and shales, where it was abandoned at 499 m (1637 ft.). The thin basal limestone of the A Subzone was not recorded. This unit is also apparently absent in other drilling in the area, consequently a faulted relationship with the Horton Group may locally be inferred. Alternatively it may not have been deposited in the area.

Bell (1958) reported that salt was intersected in the No. 2 well at a depth of 165.5 m (541 ft.). This hole was abandoned at 237.7 m (780 ft.). The No. 3 well was drilled in 1922 to a depth of 207.8 m (682 ft.) and penetrated only gypsum.

The only reported outcrop in the immediate vicinity of Falmouth Nos. 2 and 4 is reported to be the B Subzone Miller limestone (Wright, 1931), located 100 m southwest of the holes. The tops of the holes are thought to lie below this horizon. Opinions differ regarding the true thickness of the salt bed. The drillers reported a salt bed thickness of 3.35 m (11 ft.) in Falmouth No. 2. Bell (1958) concluded, however, that the true thickness may be as little as "a few inches" when corrected for steep dips. The Miller limestone outcrop reported nearby has a 10° dip and the salt horizon was intersected at approximately the same depth in both Falmouth Nos. 2 and 4. This suggests that the salt bed may be very nearly flat lying and the complex structural nature of the type section 0.5 km to the east suggests the areas are probably separated by a fault.

In 1966, Scurry-Rainbow Oil Ltd. drilled hole SR1-1 near Belmont approximately 10 km northeast of Falmouth. The hole was abandoned after intersecting 293 m (961 ft.) of interstratified limestone, shale and gypsum. This interval is probably part of the Upper Windsor and B Subzone of the Lower Windsor which, in a normal section, would overlie the main A Subzone salt unit. In this area, the salt is probably absent, possibly due to tectonic uplift and gravity sliding described in the Wentworth and Miller Creek Formations type localities by Geldsetzer et al. (1980). In these areas, recumbent folding is described in rocks immediately overlying undisturbed Vinland Formation.

In 1957, the Dominion Rock Salt Company Limited drilled two holes in exploration for salt near Mount Denson approximately 5 km north of Falmouth (Figs. 2-10 and 2-12). The first hole, DRSC-1, was drilled to a total depth of 132 m (433 ft.) and was abandoned in the Horton Group strata. The second hole, DRSC-2, was drilled to a total depth of 247 m (810 ft.) and was also abandoned in Horton Group strata. Although a thick anhydrite section was intersected, no salt or traces of salt were reported.

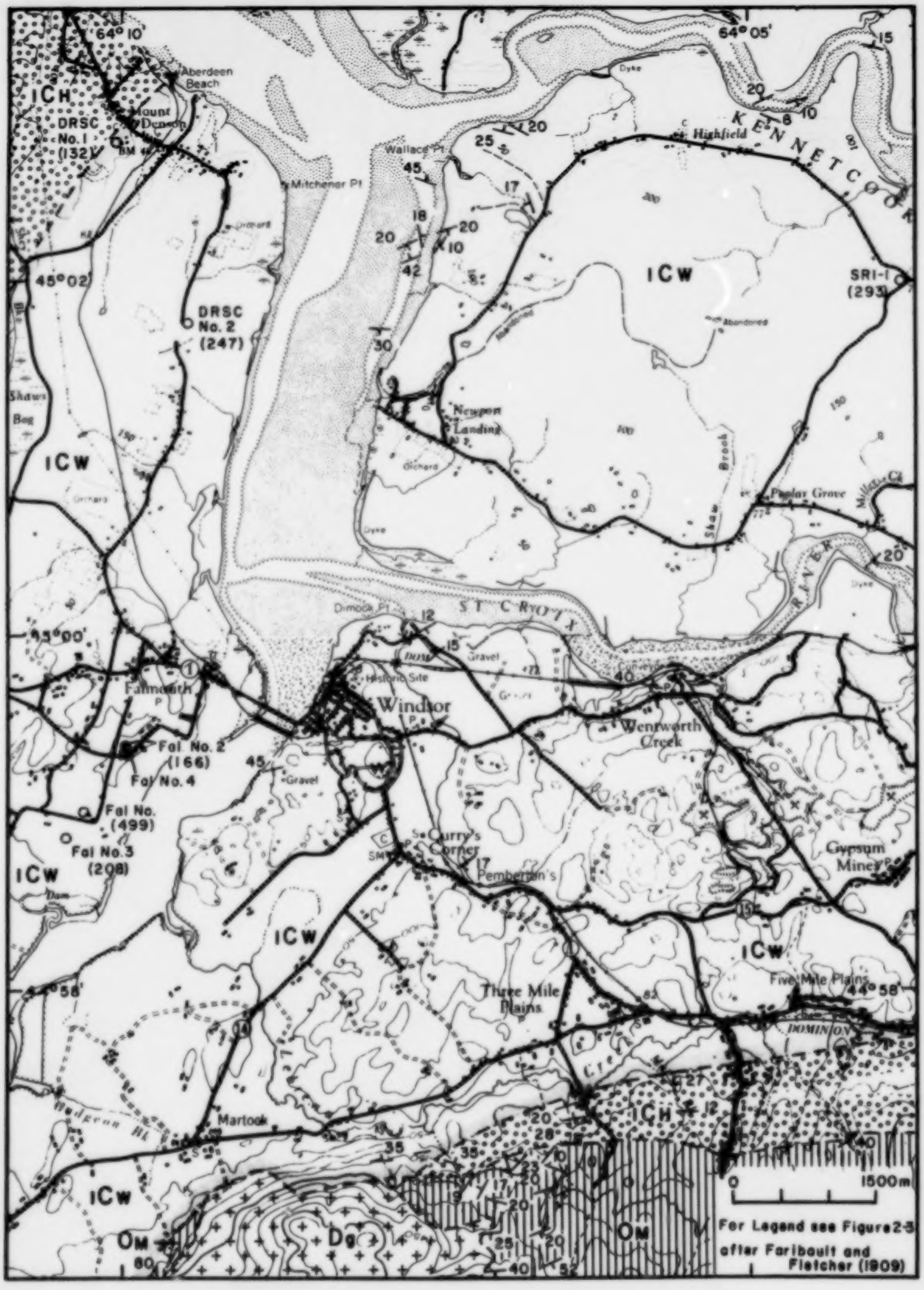
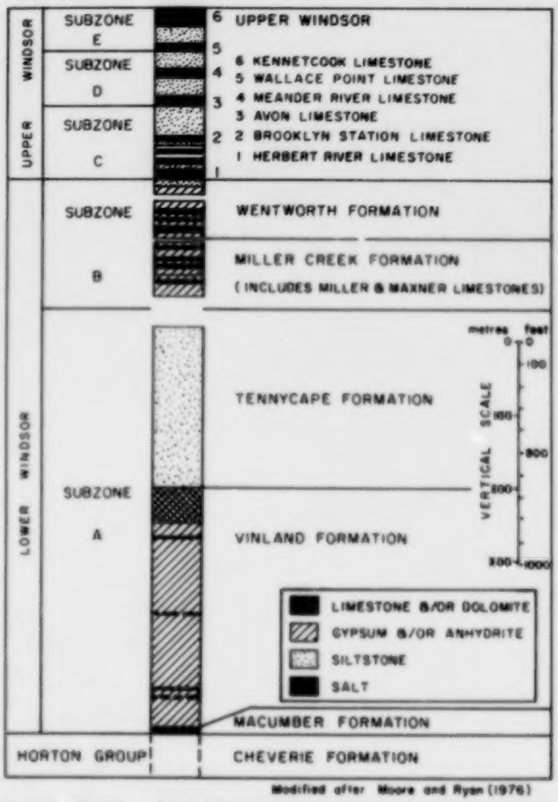

64° 10'
64° 05'
Aberdeen Beach
Mount Denson
ICH
DRSC No. 1 (132)
Kennetcook River
Highfield
Wallace Pt
Mitchener Pt
ICW
SRI-1 (293)
45°02'
DRSC No. 2 (247)
Abandoned
Newport Landing
Shaw Bog
Shaw Brook
Poplar Grove
Miller Ck
St Croix River
Dimock Pt
45°00'
Falmouth
Windsor
Historic Site
Gravel
Wentworth Creek
Fal. No. 2 (166)
Fal No. 4
Fal No. (499)
Fal No. 3 (208)
Curry's Corner
Pemberton's
Gypsum Mines
Three Mile Plains
Five Mile Plains
44°58'
Dominion
44°58'
Martock
ICH
Om
Dg
0
1500m
For Legend see Figure 2-5
after Faribault and Fletcher (1909)

Figure 2-10. Geological map, Falmouth occurrence, Hants County.


UPPER WINDSOR
SUBZONE E
SUBZONE D
SUBZONE C
6 UPPER WINDSOR
6 KENNETCOOK LIMESTONE
5 WALLACE POINT LIMESTONE
4 MEANDER RIVER LIMESTONE
3 AVON LIMESTONE
2 BROOKLYN STATION LIMESTONE
1 HERBERT RIVER LIMESTONE
LOWER WINDSOR
SUBZONE B
WENTWORTH FORMATION
MILLER CREEK FORMATION
(INCLUDES MILLER & MAXNER LIMESTONES)
SUBZONE A
TENNYCAPE FORMATION
VINLAND FORMATION
VERTICAL SCALE
metres feet
0 0
100
100
500
200
300 1000
LIMESTONE &/OR DOLOMITE
GYPSUM &/OR ANHYDRITE
SILTSTONE
SALT
MACUMBER FORMATION
HORTON GROUP
CHEVERIE FORMATION

Modified after Moore and Ryan (1976)

Figure 2-11. Stratigraphic column, western Minas Sub-basin.

GEOPHYSICS

The area in the immediate vicinity of the Falmouth occurrence is covered by Nova Scotia Research Foundation Bouguer anomaly maps (Fig. 2-13). A poorly defined, very low relief gravity low is apparent in the vicinity of Falmouth Nos. 2, 4 and 1. This low appears to extend with uncertain relationship further to the east and also to the west. The drilling in the area has not established the presence of a significant salt mass which could cause the anomaly. Since the anomaly is of such low relief, it may reasonably be attributed to lithology and thickness variations unrelated to salt.

ECONOMIC CONSIDERATIONS

The Falmouth occurrence is believed to consist mainly of anhydrite with halite. Potash is not known to be present. The salt occurs as a thin (3.35 m) bed in gypsum and was intersected at a depth of 165.5 m (543 ft.). This evaporite section is not outlined by a gravity low. An evaporated brine salt sample was reported by Wright (1931) and analyzed by A. E. Flinn at Acadia University as shown in Table 2-2. The brine is essentially a salt brine with minor calcium sulphate and is typical of low $CaSO_4$ salt springs in Nova Scotia.

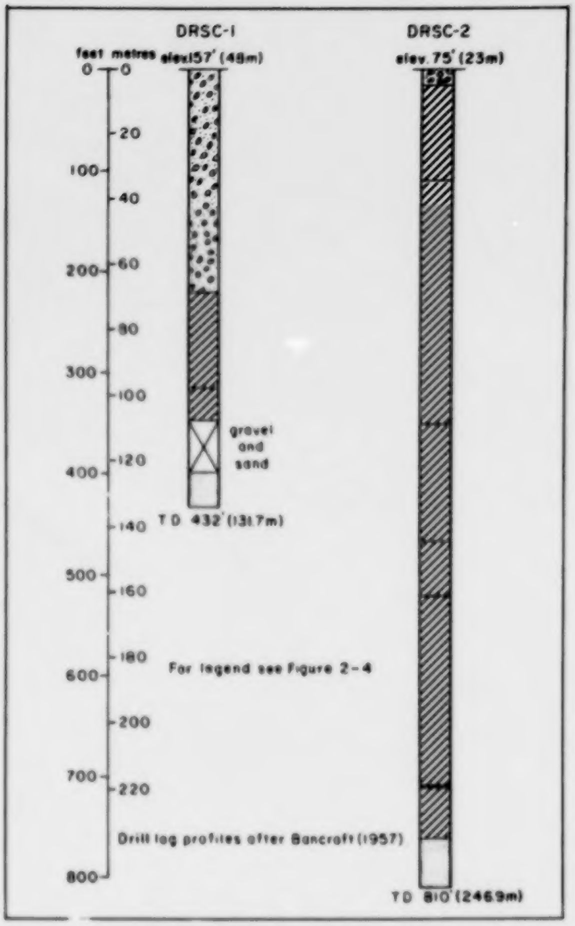
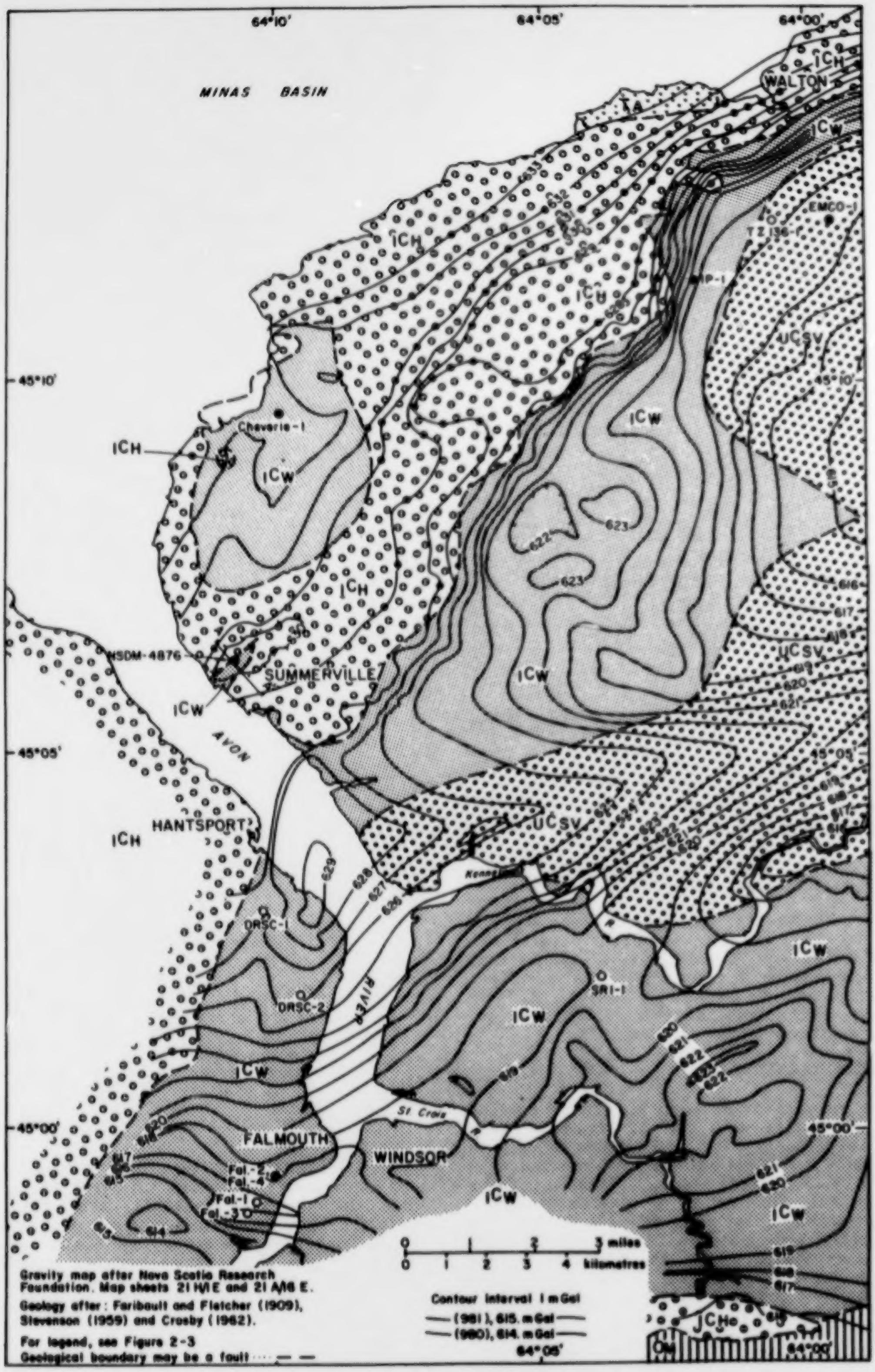

DRSC-1
DRSC-2
feet metres
elev.157' (48m)
elev.75' (23m)
0 0
20
100
40
200
60
80
300
100
gravel and sand
400
120
140
TD 432' (131.7m)
500
160
180
600
For legend see Figure 2-4
200
700
220
Drill log profiles after Bancroft (1957)
800
TD 810' (246.9m)

Figure 2-12. Drillhole profiles, Mount Denson, Hants County, Nova Scotia. (For locations see Fig. 2-10)

Table 2-2. Chemical analyses, evaporated brine, Falmouth occurrence (Wright, 1931).

Insolubles	0.12%
Iron and aluminum	0.05%
Lime	1.05%
Sulphuric anhydrite	1.80%
Sodium chloride	97.00%
Total	100.02%

An accurate estimate of the lateral extent and thickness variation of the salt is not possible from the available data. It is most likely a thin lense or tongue of salt within the thick basal anhydrite (Vinland Formation) of the Windsor Group. This deposit is not considered to be of economic importance.


64°10'
64°05'
64°00'
MINAS BASIN
WALTON
ICH
ICW
EMCO-I
TZ 136-1
P-I
UCSV
45°10'
Cheverie-I
ICH
ICW
622
623
623
ICW
NSDM-4876
SUMMERVILLE
ICW
AVON
45°05'
HANTSPORT
ICH
UCSV
DRSC-I
DRSC-2
RIVER
SRI-I
ICW
ICW
St. Croix
45°00'
FALMOUTH
WINDSOR
Fal.-2
Fal.-4
Fal.-1
Fal.-3
ICW
ICW
JCHo
Om
0 1 2 3 miles
0 1 2 3 4 kilometres
Contour interval 1 mGal
(981), 615. mGal
(980), 614. mGal
64°05'
64°00'

Gravity map after Nova Scotia Research Foundation. Map sheets 21 H/1 E and 21 A/16 E.

Geology after: Faribault and Fletcher (1909), Stevenson (1959) and Crosby (1962).

For legend, see Figure 2-3

Geological boundary may be a fault ···· — —

Figure 2-13. Bouguer gravity anomaly map, Falmouth, Summerville and Walton occurrences, Hants County.

KENNETCOOK OCCURRENCE

LOCATION

The Kennetcook occurrence is located near the Village of Kennetcook (NTS 11E/04E) in central Hants County. Kennetcook is located 45 km northeast of Windsor, 13 km south of Noel and is near the southern border of the Kennetcook Valley (Figs. 1-4, 1-10 and 2-14). The area is readily accessible by paved and gravel highways.

The terrain in the vicinity is typical of the Carboniferous Lowlands with gently rolling hills and elevations rarely exceeding 75 m. The Rawdon Hills, with elevations of up to 200 m, are located several kilometres to the south.

HISTORICAL BACKGROUND

At Kennetcook salt was intersected by Anthony No. 3, the petroleum exploration borehole drilled by Nova Scotia Oil and Gas Company in 1944-45. Two other holes (Anthony Nos. 1 and 2) were also drilled for petroleum in the vicinity of the discovery hole, but were abandoned at shallow depths due to drilling difficulties. The geology of the area was described and mapped by Stevenson (1959) (Fig. 2-14). The many salt springs reported in the area indicate salt is being actively dissolved at depth. The area was assessed for its potash potential by Wright (1931), when several salt springs in the vicinity of Kennetcook were located and analyzed.

In 1975, Soquip A.C.C. et al., Noel No. 1 was drilled for petroleum 4.2 km north-northeast of Kennetcook near White Settlement. This hole penetrated the entire Carboniferous section and was abandoned after reaching the pre-Carboniferous basement without intersecting salt.

GEOLOGY

The geology in the Kennetcook vicinity (Kennetcook map area 11E/04) was mapped by Stevenson (1959, Fig. 2-14). The major rock units in the area are similar to those in the Clarksville occurrence.

A major northeasterly trending fault was indicated by Stevenson (1959) between the Windsor and Horton Groups on the southern border. The Windsor Group in this area lies within the severely deformed tectonic zone (Fig. 2-2) described by Giles (1977). Very thick (apparent) limestone intersections are indicated in the several holes drilled in the area which suggests that bedding dips are probably very steep. Steep bedding dips were mapped by Stevenson (1959).

The Kennetcook occurrence is defined in a single borehole, Anthony No. 3, drilled by Nova Scotia Oil and Gas Company (Figs. 2-14 and 2-15). Bell (1958) reported that Stevenson picked the top of the Windsor Group at 265.5 m (871 ft.) and the top of the Horton Group at 555 m (1822 ft.). The anhydrite in the interval 656.5-662.6 m (2154-2174 ft.) was considered to be caved material. The salt sections reported by Bell (1958) are 404.5-409.3 m (1327-1343 ft.), 7% salt and 409.3-423.4 m (1343-1309 ft.), up to 88% salt. The salt interval is thin and appears to lie at or near the normal stratigraphic position of the main Windsor Group salt. A large portion of the Windsor Group above the salt is apparently absent in the borehole. Scotch Village Formation rocks are reported to a depth of 265.5 m (871 ft.). The rocks described above the salt and beneath the Scotch Village Formation comprise red shale and sandstone and may be equivalent to the Tennycape Formation of Weeks (1948). Structural complexity and/or post-Windsor erosion are inferred to be responsible for the present configuration (Fig. 2-16).

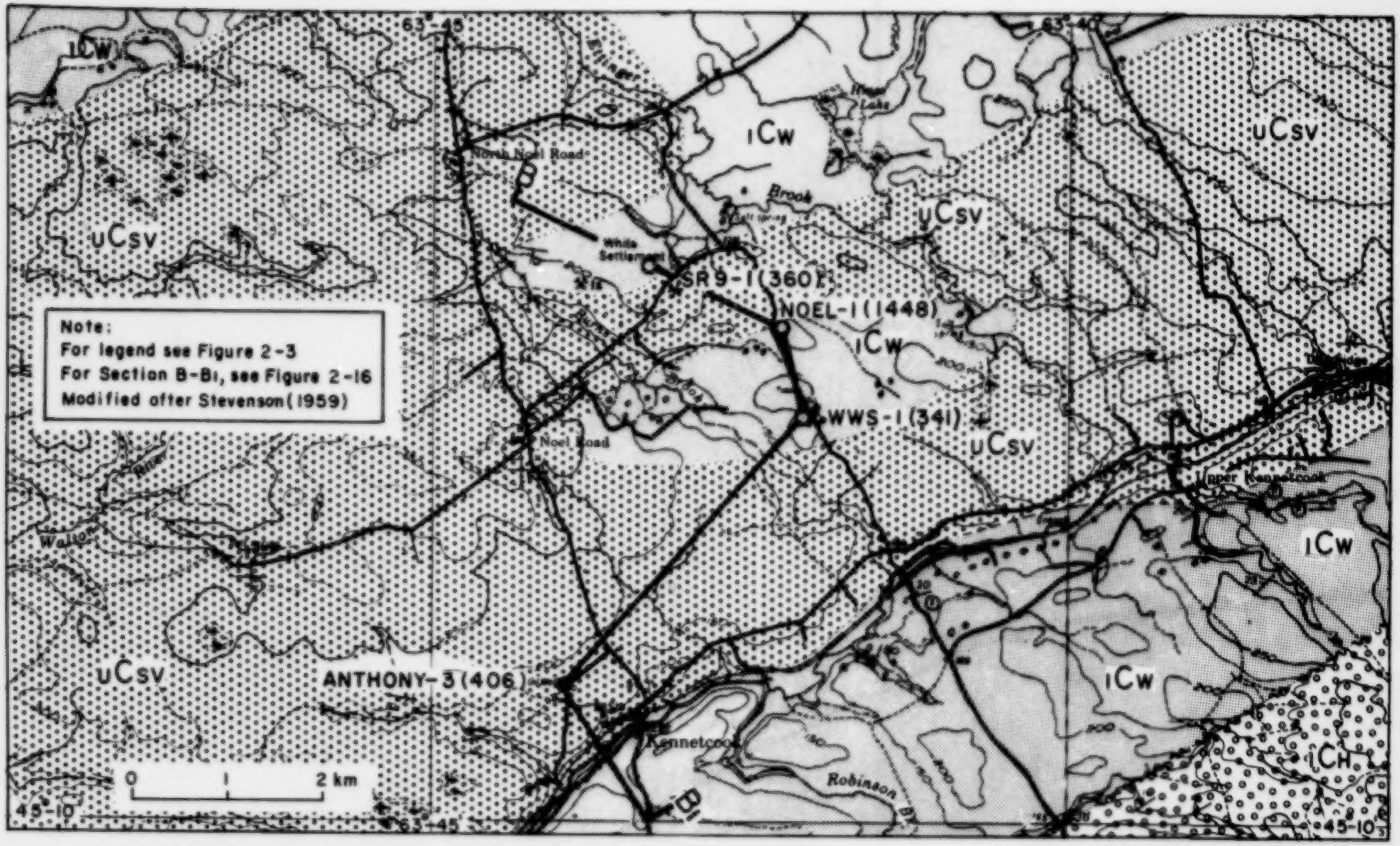
Numerous salt springs in this area confirm that salt is present and that it is actively undergoing dissolution by circulating ground water. Many of the springs are located in areas underlain by Scotch Village Formation rocks. The source of the brines is believed to lie in the highly fractured and folded Windsor Group rocks beneath.

The structural configuration of the salt in the area is unknown. The distribution of the salt in the area may be related to several factors. Folding, faulting and circulating groundwaters removed much of the salt that was not sealed. Many of the drillholes in the vicinity of the Kennetcook deposit did not intersect salt. The WS-1 drillhole of Dresser Minerals, 0.8 km to the south of Noel No. 1, is reported to have intersected red shales and gypsum overlying the Macumber limestone at 336 m (1102 ft.). This hole was stopped in Horton Group at 341.4 m (1120 ft.). Scurry Rainbow Oil Ltd. SR9-1, drilled 1.5 km northwest of Noel No. 1, penetrated thickly interbedded limestone and siltstone to a depth of 360 m (1181 ft.). Another hole, SR21-1, was drilled near Gormanville approximately 5 km northwest of SR9-1. This hole intersected interbedded red and grey siltstone, shale and sandstone typical of the Scotch Village Formation to a total depth of 331 m. Scurry-Rainbow Oil Ltd. also drilled SR8-1 approximately 4 km south-southwest of Anthony No. 3 (Fig. 2-14). This hole penetrated interbedded limestone, siltstone and gypsum to a total depth of 128 m (420 ft.). A severely disturbed stratigraphic and structural situation is probable in this area.

GEOPHYSICS

The area in the vicinity of the Kennetcook occurrence is included in Bouguer gravity anomaly map sheet 11E/04 at a scale of two inches equals one mile and a simplified version is included in Figure 2-8. In addition, a small area near Upper Kennetcook is covered on a Bouguer gravity map by Leslie (1967) at a scale of one inch equals 1000 feet.

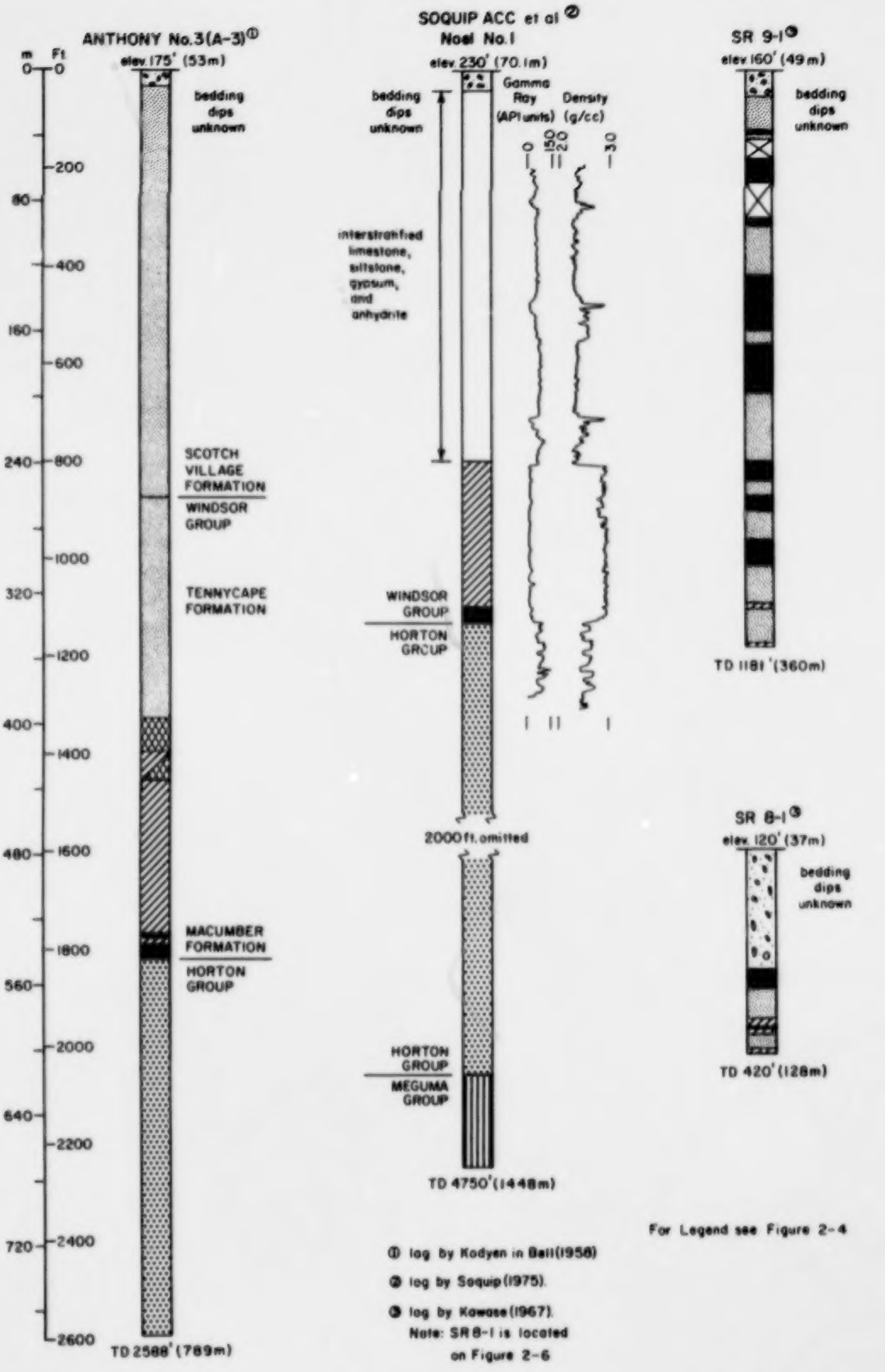
The Kennetcook occurrence is located at the northeastern end of a narrow, trough shaped gravity low (25 mGal) that extends parallel to the Windsor Group and Horton-Meguma Groups contact. Much of the drilling in the Kennetcook area was directed along the northwestern flank of the gravity trough and, therefore, the Bouguer gravity minimum has yet to be tested. A structural configuration similar to that found in the Clarksville occurrence is probable. The large



Note:
For legend see Figure 2-3
For Section B-B1, see Figure 2-16
Modified after Stevenson (1959)

63°45'
63°40'
lCw
lCw
uCsv
North Noel Road
Brook
uCsv
uCsv
White Settlement
SR9-1(360)
NOEL-1(1448)
lCw
WWS-1(341)
uCsv
Noel Road
Upper Kennetcook
lCw
Walton
uCsv
ANTHONY-3(406)
lCw
Kennetcook
lCH
Robinson Br
B1
0
1
2 km
45°10'
63°45'
45°10'

Figure 2-14. Geology in the vicinity of the Kennetcook occurrence, Hants County.


m
Ft
0
0
200
80
400
160
600
240
800
1000
320
1200
400
1400
480
1600
1800
560
2000
640
2200
720
2400
2600
ANTHONY No.3(A-3)①
elev.175' (53m)
bedding dips unknown
SCOTCH VILLAGE FORMATION
WINDSOR GROUP
TENNYCAPE FORMATION
MACUMBER FORMATION
HORTON GROUP
TD 2588' (789m)
SOQUIP ACC et al ②
Noel No.1
elev.230' (70.1m)
bedding dips unknown
Gamma Ray (API units)
Density (g/cc)
0
150
2.0
3.0
interstratified limestone, siltstone, gypsum, and anhydrite
WINDSOR GROUP
HORTON GROUP
2000 ft. omitted
HORTON GROUP
MEGUMA GROUP
TD 4750' (1448m)
SR 9-1③
elev.160' (49m)
bedding dips unknown
TD 1181' (360m)
SR 8-1③
elev.120' (37m)
bedding dips unknown
TD 420' (128m)

For Legend see Figure 2-4

① log by Kodyen in Bell(1958)

② log by Soquip(1975).

③ log by Kawase(1967).
Note: SR 8-1 is located on Figure 2-6

Figure 2-15. Drillhole profiles, Kennetcook occurrence. (For locations see Fig. 2-14).

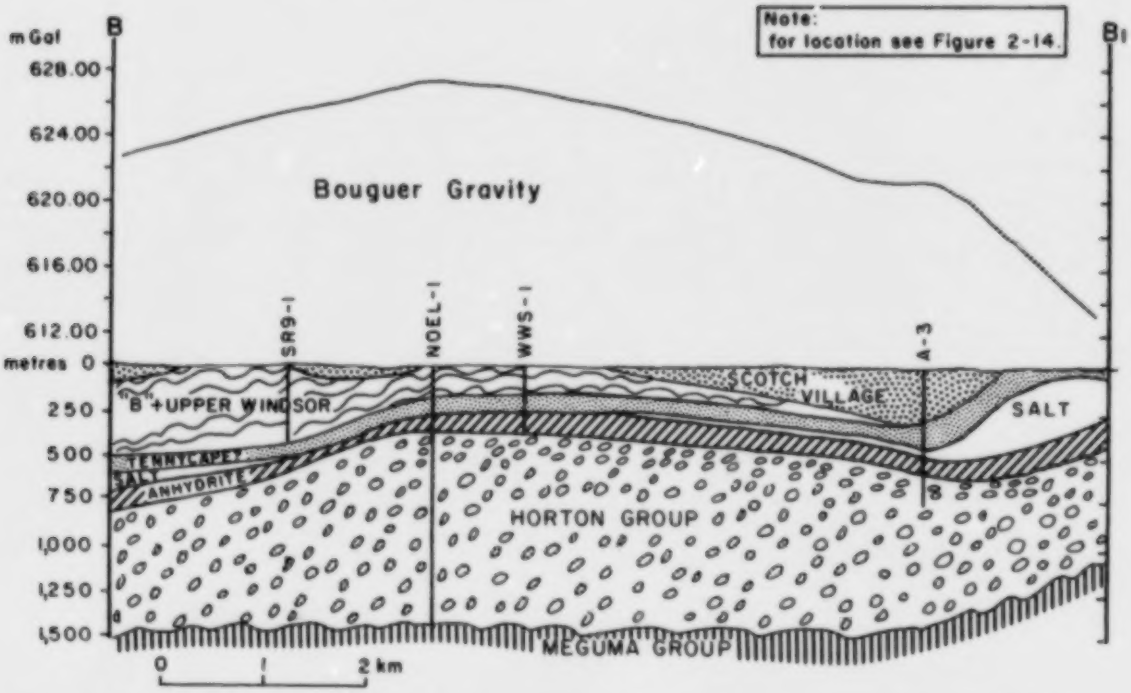


Figure 2-16. Geology and Bouguer gravity cross-section, Kennetcook occurrence, Hants County.

salt mass inferred to be south and east of the area is probably an extension of that inferred in the Clarksville area.

GEOCHEMISTRY

Cole (1930a) described and analyzed three springs located in the vicinity of Kennetcook. The Ettinger Salt Pond (No. 33) is reported to occur on the property of Caleb Ettinger, approximately 5.6 km north of Kennetcook Corner Post Office. This spring is probably the same as the spring located by Stevenson (1959) 1 km northeast of SR9-1 near White Settlement. The Ettinger Brook Spring (No. 34) is reported to be located near a gypsum outcrop on the western bank of Ettinger Brook approximately 2.4 km upstream from its junction with the Kennetcook River. This spring is probably the same one located by Stevenson (1959) 1.9 km east of Soquip et al., Noel No. 1. A third salt spring, Willard Rine's Well (No. 35), was reported by Cole (1930a) to occur 3.2 km northeast of Kennetcook Corner Post Office. Wright (1931) reported the well to be "20 feet deep in gravel, partially filled by very salt water ... A small salt spring lies about 1/4 mile west of the salt well, on the west side of Capt. Scott Brook at its junction with the Kennetcook River".

Spring No. 33 has a high content of $CaSO_4$, indicating dissolution of gypsum or anhydrite in addition to NaCl (Table 2-3).

Windsor Group rocks coincident with Spring No. 34 occur in a small outcrop area near White Settlement. In most of the area, however, the Windsor Group occurs peripheral to the Scotch Village Formation which caps the sequence.

Baar (1966) analyzed weight per cent Br/NaCl from the Anthony No. 3 (Table 2-4). The high value of 0.0195 at a depth of 428 m (1405 ft.) approaches the potash salt deposition threshold and is encouraging for further potash exploration.

ECONOMIC CONSIDERATIONS

Borehole cuttings from the Kennetcook occurrence indicate the presence of halite but not potash. The upper salt in Anthony No. 3 is logged at 404.5 m to 409.3 m (1327-1343 ft.) with the main section at 409.3 m to 423.4 m (1343-1389 ft.). The structural configuration of the occurrence is not known. This salt occurs near the top of the basal anhydrite of the Windsor Group and is overlain by a thick section of red and grey green sandstone and shale assigned to the Windsor Group (Tennycape Formation? of Weeks, 1948) and the (post Windsor) Scotch Village Formation. The salt appears to be limited to the north; further drilling will be required on the gravity low to validate the salt. The area is not readily accessible to tide water shipping. The presence of salt springs in the area indicates salt is present in the subsurface and is being dissolved by circulating groundwater. The occurrence, as presently known, is not considered to be of economic importance, but there are probably other salt deposits and possibly potash in the area.

Table 2-3. Chemical analyses Kennetcook area salt springs*

Spring No.	33	34	35
FIELD NOTES AT TIME OF SAMPLING			
Temperature of atmosphere, °F	n.d.	n.d.	n.d.
Temperature of brine, °F	n.d.	n.d.	n.d.
Baume degrees	n.d.	n.d.	n.d.
Equivalent specific gravity.	-	-	-
LABORATORY NOTES			
Specific gravity at 60°F	1.0000	1.0188	1.014
Total solids at 110°C	0.79	2.43	2.08
Reaction	N	N	N
ANALYSES OF SOLIDS			
Na Per cent	23.77	32.24	32.15
K Per cent	0.14	0.06	n.d.
Ca Per cent	10.58	3.90	4.00
Mg Per cent	0.40	0.54	0.42
SO_4 Per cent	25.67	12.43	12.91
Cl Per cent	37.74	48.72	46.06
Br Per cent	n.d.	none	n.d.
I Per cent	n.d.	none	n.d.
Totals	98.30	97.89	95.54
HYPOTHETICAL COMBINATIONS			
$CaSO_4$ Per cent	35.97	13.26	13.60
$CaCl_2$ Per cent	-	-	-
$MgSO_4$ Per cent	0.35	2.21	2.08
$MgCl_2$ Per cent	1.29	-	-
K_2SO_4 Per cent	-	0.12	-
KCl Per cent	0.27	-	-
Na_2SO_4 Per cent	-	1.98	2.27
NaCl Per cent	60.42	80.32	77.58
Totals	98.30	97.89	95.53

*Cole (1930a).

Table 2-4. Bromine analyses, Anthony No. 3, Kennetcook occurrence*

Location	Depth in Feet	Wt. Per cent Br/NaCl
Kennetcook	1366	0.0050
Kennetcook	1375	0.0057
Kennetcook	1383	0.0053
Kennetcook	1405	0.0195

*Baar (1966)

SHUBENACADIE-STEWIACKE DEPOSIT

LOCATION

The Shubenacadie-Stewiacke deposit is located in Colchester and eastern Hants Counties (NTS 11E/06, 11E/04W and 11E/03), Nova Scotia (Figs. 1-4, 1-10 and 2-17). The deposit underlies a large portion of the Shubenacadie and Stewiacke River valleys. The area is readily accessible by a system of paved and gravel highways connected to the Trans-Canada Highway 104, between Truro and Halifax. The Canadian National Railway mainline between Halifax and Truro parallels the Trans-Canada Highway and passes through the centre of the area. The Halifax International Airport is located 40 km southwest of Stewiacke near the geographical centre of the deposit area.

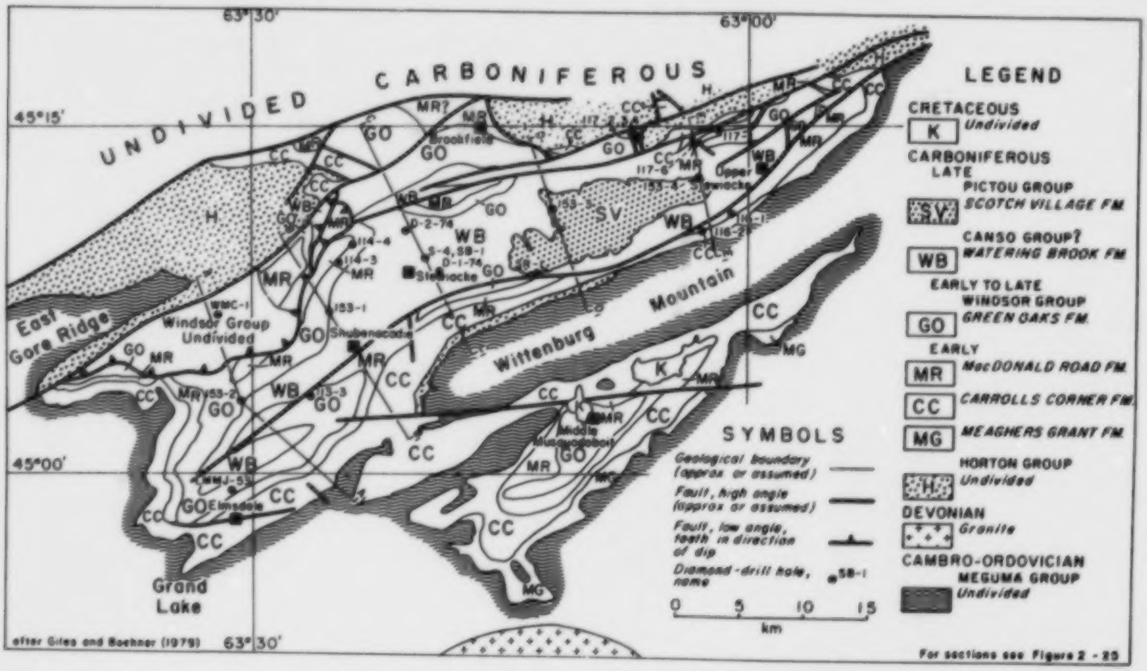

63°30'
63°00'
45°15'
45°00'
UNDIVIDED CARBONIFEROUS
East Gore Ridge
Windsor Group Undivided
Brookfield
Stewiacke
Shubenacadie
Upper Stewiacke
Wittenburg Mountain
Middle Musquodoboit
Elmsdale
Grand Lake
H
SV
WB
GO
MR
CC
MG
K
MR?
WMC-1
114-4
114-3
153-1
153-2
153-3
153-4
113-3
D-2-74
S-4, SB-1
D-1-74
117-2,3,4
117-5
117-6
116-1
116-2
MMJ-53
LEGEND
CRETACEOUS
K Undivided
CARBONIFEROUS
LATE
PICTOU GROUP
SV SCOTCH VILLAGE FM
CANSO GROUP?
WB WATERING BROOK FM
EARLY TO LATE
WINDSOR GROUP
GO GREEN OAKS FM
EARLY
MR MacDONALD ROAD FM
CC CARROLLS CORNER FM
MG MEAGHERS GRANT FM
HORTON GROUP
H Undivided
DEVONIAN
Granite
CAMBRO-ORDOVICIAN
MEGUMA GROUP
Undivided
SYMBOLS
Geological boundary (approx or assumed)
Fault, high angle (approx or assumed)
Fault, low angle, teeth in direction of dip
Diamond-drill hole, name
SB-1
0 5 10 15
km
after Giles and Boehner (1979)
For sections see Figure 2 - 25

Figure 2-17. Geological map, Shubenacadie-Stewiacke deposit.

The topography in the deposit area is typical of the Carboniferous Lowlands where the gently rolling hills have elevations rarely exceeding 75 m. The Valley is bordered on the southeast by the central Nova Scotia Uplands with elevations up to 170 m and on the north by uplands with elevations of 150-225 m.

HISTORICAL BACKGROUND

Hayes (1931) compiled a regional assessment of the potash and salt potential of Nova Scotia. In this report the Shubenacadie-Stewiacke Valley was discussed by Wright (1931) as part of the "Shubenacadie Basin". The assessment produced inconclusive results due mainly to the scarcity of outcrop and a limited time for field investigation. A single salt spring was located near Otter Brook in the northeastern corner of the Valley.

Intensive drilling and exploration for base metal deposits has been undertaken more recently by many exploration companies following the discovery of the Gays River zinc and lead deposit by Imperial Oil Limited, Cuvier Mines Limited and Getty Mines Limited. The abundant drill data produced by this exploration activity together with a field mapping project by the Nova Scotia Department of Mines and Energy have provided a better understanding of the Windsor Group stratigraphy and structure in the area. A significant number of the base metal exploration drillholes unintentionally encountered salt in the area (Giles and Boehner, 1979 and 1982a). Most of these holes were drilled by St. Joseph Exploration and Noranda Exploration Limited in the more central parts of the basin. In addition, salt was intersected in holes drilled by Aurum Gold Mines Limited, Amax Exploration, Denison Mines Ltd. and Dresser Minerals. Subsequently, in 1975 a joint exploration venture for potash was undertaken by St. Joseph Exploration Ltd. and Noranda Exploration Limited (Sangster et al., 1975). Four deep holes were drilled into a thick salt zone, but potash mineralization was not encountered. The latest deep drilling in the area was undertaken by Pacific Coast Exploration (U.S. Borax) near Stewiacke where SB-1 (Fig. 2-18) was drilled through the entire Windsor stratigraphic section to the underlying Horton Group. A similarily thick section of salt was intersected in this hole. Two of these deep holes, St. Joseph-Noranda 153-1 and Pacific Coast SB-1, were sampled for analyses through all salt intervals by the Nova Scotia Department of Mines and Energy.

GEOLOGY

Previous workers in the area, including Faribault and Fletcher in the early 1900's and Stevenson in the late 1950's mapped the Windsor Group as an undivided map unit. The Nova Scotia Department of Mines and Energy has recently remapped (Fig. 2-17) and described in more detail the stratigraphy (Fig. 2-18) and structure of the Windsor Group in the area (Giles and Ryan, 1976; Giles, 1977; Boehner, 1977b and c; Giles and Boehner, 1979; Utting, 1980; Boehner, 1980a; and Giles and Boehner, 1982a).

The Shubenacadie-Stewiacke Valley is underlain by a sequence of limestone, dolostone, gypsum, anhydrite, halite and red-maroon and green siltstone and sandstone belonging to the Windsor Group (Fig. 2-18). The Windsor Group rocks overlie the Lower Carboniferous rocks of the Horton Group which comprise interstratified grey and greenish-grey and red sandstones, grits and conglomerates and maroon siltstones and shales. The Horton Group rocks lie with distinct angular unconformity on the folded slates and metasandstones of the Meguma Group. On the northern border of Wittenburg Mountain (southern side of Stewiacke Valley) the Horton Group thins and pinches out on the Meguma Group basement. Here it is composed of a conglomerate derived from the Meguma Group.

The basal unit of the Windsor Group in the area is called the Gays River Formation (Giles et al., 1979) and overlies the Horton Group with apparent conformity, but may be found directly on the Meguma basement rocks without intervening Horton Group. In such cases the less common and thicker bank facies is best developed. It occurs principally in the extreme southeastern part of the Shubenacadie-Stewiacke area and within the Musquodoboit Valley. Upper Carboniferous sandstone and shale occur in the more central parts of the Valley.

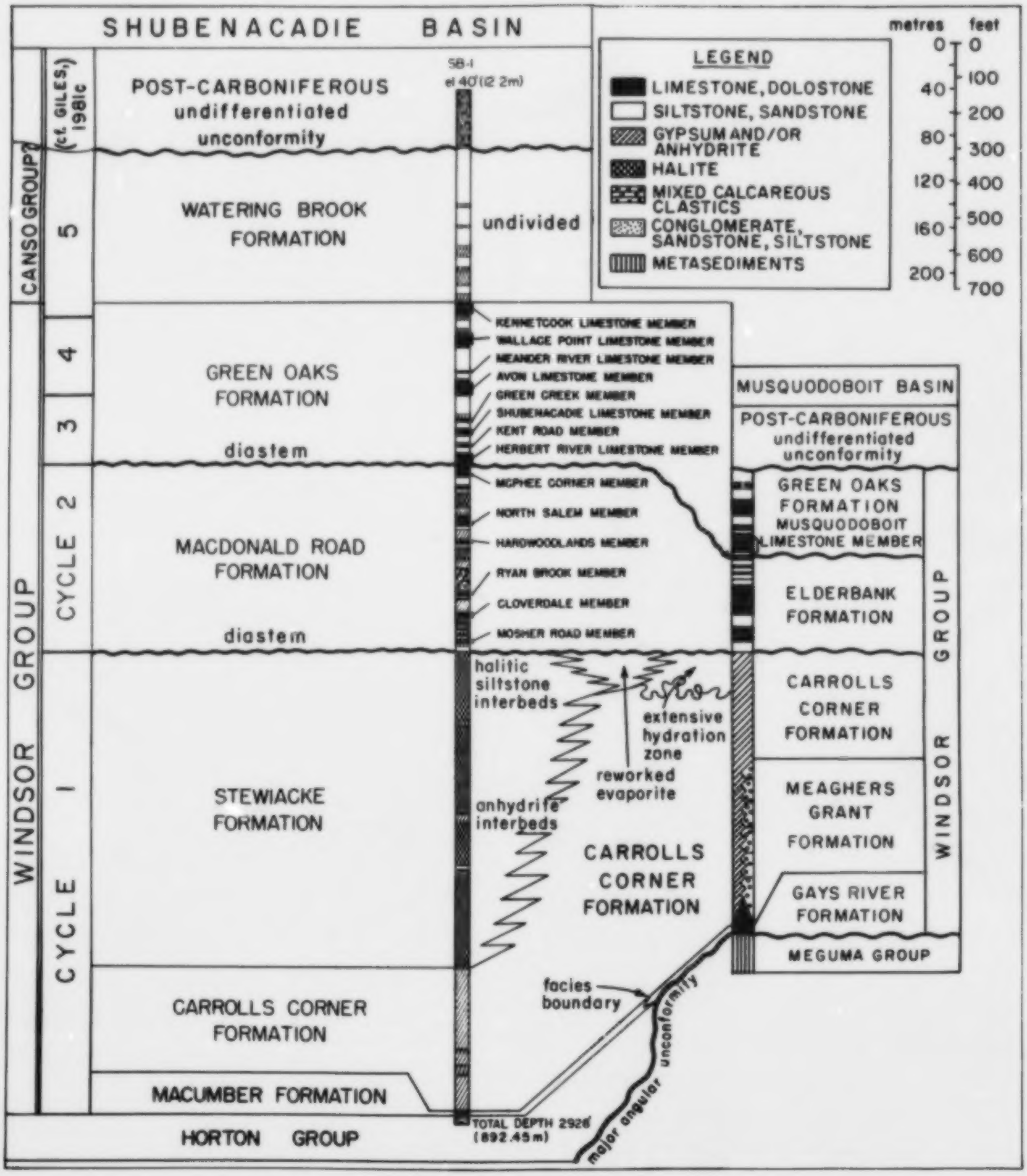
The Shubenacadie-Stewiacke area has the outline of an elongate triangular valley trending northeast-southwest and is separated from the Musquodoboit Valley to the southeast by Wittenburg Mountain and its topographic equivalent highland area from Gays River to Grand Lake. The southeastern border appears to be relatively undisturbed sedimentary contact for the most part, although some folding and faulting are present particularly near Wittenburg Mountain. Giles (1978) indicated a northeast-southwest trending fault on the southeastern border of the area. This fault extends from near Grand Lake to the extreme northeastern end of the area. The northwestern border is much more complex due to faulting and severe structural complications and gives the area a graben-like structural configuration. On its extreme southwestern end the northwestern border is defined by the East Gore Ridge (an extension of the Rawdon Hills Highlands). The northeastern end of this border is marked by Carboniferous Highlands comprising folded rocks of the Horton Group. The central portion of the border is not readily discernible on the basis of topography, but is recognized as a major structural break (fault zone). This structural break continues to the northeast and southwest as a complex fault system (Fig. 2-17).

A large scale overturned section involving the Green Oaks and MacDonald Road Formations in a nappe-like fold was described in the McPhee Corner-North Salem area (Giles, 1977) adjacent to the East Gore Ridge on the northwestern border.

Very complex structural relations are evident from mapping and drilling adjacent to the Carboniferous Highlands portion of the northwestern border. The border is concluded to be a complex fault system with slices of Windsor rocks faulted against the folded and faulted Horton rocks. Units from all stratigraphic levels can be found in faulted relationship with Horton Group rocks. Mineral shows and prospects of interest are relatively abundant along this contact with the host units represented from the base through to the upper portion of the Windsor Group succession. The Windsor Group rocks in the Shubenacadie Basin form a synclinorium (graben) trending northeast-southwest, generally with younger units in the central portion and older units around the periphery. The axial area of the graben contains a large mass of relatively undisturbed stratified salt.

The stratigraphic succession (Fig. 2-18) within the Shubenacadie-Stewiacke Valley was described by Boehner (1984) and Giles and Boehner (1979, 1982a). The following is a summary of this work.

The total section of the Windsor Group in the Shubenacadie-Stewiacke Valley is approximately 760 m thick and its stratigraphic position within the Carboniferous succession is indicated in Figure 2-18. Five formations are recognized as comprising the Windsor Group in the area. The Gays River Formation-Macumber Formation is locally fossiliferous dolostone 1-60 m thick resting with angular unconformity on pre-Carboniferous basement rocks or conformably on Early Carboniferous Horton Group rocks. It is conformably overlain by the Carrolls Corner Formation, which is a thick section (up to 400 m) of pure anhydrite. The Stewiacke Formation is a thick section (up to 300 m) of rock salt (halite) that conformably overlies and appears to be, in part, a stratigraphic equivalent of the Carrolls Corner Formation. The Carrolls Corner and Stewiacke Formations (where present) are disconformably overlain by the MacDonald Road Formation (Fig. 2-18), a 162 m thick cyclic sequence of marine carbonate sheets, red-maroon and green lutite and arenite, anhydrite, and locally halite. The halite units are thin discontinuous lenses (less than 10 m) and are of very limited economic significance. The MacDonald Road Formation is disconformably overlain by the Green Oaks Formation (Figs. 2-18, and 2-19), a 143 m thick sequence of marine carbonate sheets interbedded with red-maroon and green siltstone and sandstone and locally anhydrite. The Green Oaks Formation is conformably overlain by a sequence of grey-green and maroon lutite rocks interbedded with gypsum, anhydrite and halite assigned to the Watering Brook Formation which may belong to the Canso Group.



SHUBENACADIE BASIN
metres
feet
0
40
80
120
160
200
0
100
200
300
400
500
600
700
LEGEND
LIMESTONE, DOLOSTONE
SILTSTONE, SANDSTONE
GYPSUM AND/OR ANHYDRITE
HALITE
MIXED CALCAREOUS CLASTICS
CONGLOMERATE, SANDSTONE, SILTSTONE
METASEDIMENTS
(cf. GILES, 1981c)
POST-CARBONIFEROUS undifferentiated unconformity
SB-1
el 40'(12.2m)
CANSO GROUP?
5
WATERING BROOK FORMATION
undivided
4
3
GREEN OAKS FORMATION
diastem
KENNETCOOK LIMESTONE MEMBER
WALLACE POINT LIMESTONE MEMBER
MEANDER RIVER LIMESTONE MEMBER
AVON LIMESTONE MEMBER
GREEN CREEK MEMBER
SHUBENACADIE LIMESTONE MEMBER
KENT ROAD MEMBER
HERBERT RIVER LIMESTONE MEMBER
CYCLE 2
MACDONALD ROAD FORMATION
diastem
MCPHEE CORNER MEMBER
NORTH SALEM MEMBER
HARDWOODLANDS MEMBER
RYAN BROOK MEMBER
CLOVERDALE MEMBER
MOSHER ROAD MEMBER
WINDSOR GROUP
CYCLE 1
STEWIACKE FORMATION
halitic siltstone interbeds
anhydrite interbeds
extensive hydration zone
reworked evaporite
CARROLLS CORNER FORMATION
CARROLLS CORNER FORMATION
MACUMBER FORMATION
HORTON GROUP
TOTAL DEPTH 2926' (892.45m)
facies boundary
major angular unconformity
MUSQUODOBOIT BASIN
POST-CARBONIFEROUS undifferentiated unconformity
GREEN OAKS FORMATION
MUSQUODOBOIT LIMESTONE MEMBER
ELDERBANK FORMATION
CARROLLS CORNER FORMATION
MEAGHERS GRANT FORMATION
GAYS RIVER FORMATION
MEGUMA GROUP
WINDSOR GROUP

Figure 2-18. Stratigraphic column, Shubenacadie-Stewiacke deposit.

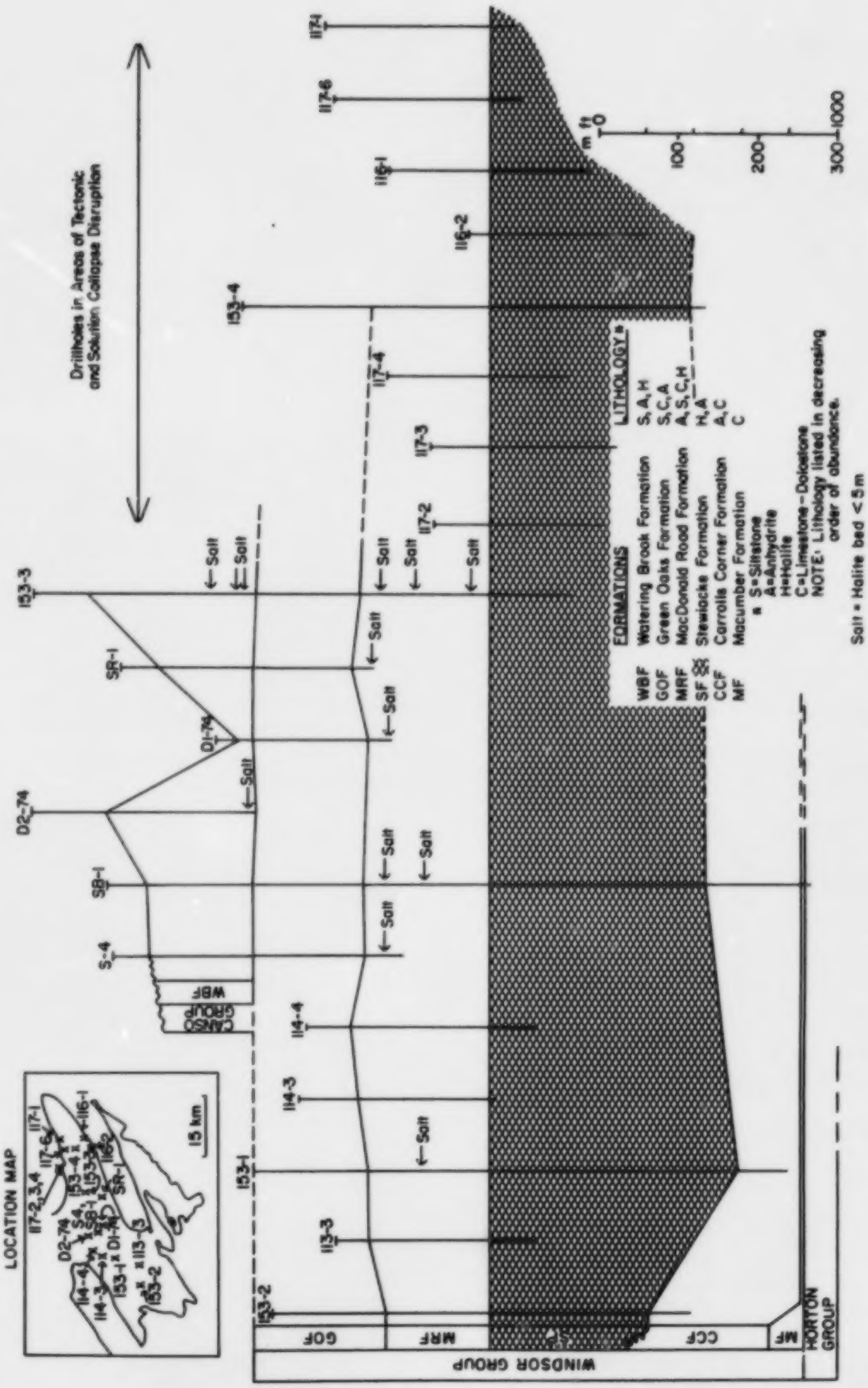

LOCATION MAP
117-2,3,4
117-6
117-1
116-1
116-2
D2-74
S4
SB-1
153-4
153-3
D1-74
SR-1
113-3
114-4
114-3
153-1
153-2
15 km
WINDSOR GROUP
GOF
MRF
SF
CCF
MF
HORTON GROUP
CANSO GROUP
WBF
153-2
113-3
153-1
114-3
114-4
S-4
SB-1
D2-74
D1-74
SR-1
153-3
117-2
117-3
117-4
153-4
116-2
116-1
117-6
117-1
Salt
Drillholes in Areas of Tectonic and Solution Collapse Disruption
m
ft
0
100
200
300
1000
FORMATIONS
LITHOLOGY*
WBF Watering Brook Formation S, A, H
GOF Green Oaks Formation S, C, A
MRF MacDonald Road Formation A, S, C, H
SF Stewiacke Formation H, A
CCF Carrolls Corner Formation A, C
MF Macumber Formation C
* S=Siltstone
A=Anhydrite
H=Halite
C=Limestone-Dolostone
NOTE: Lithology listed in decreasing order of abundance.
Salt = Halite bed <5m

Figure 2-19. Generalized correlation of drillholes intersecting the Shubenacadie-Stewiacke salt deposit.

Stevenson (1959) described the uppermost Windsor rocks in the Shubenacadie and Kennetcook map areas as being locally overlain by a thin veneer of buff to grey sandstone and red shale which he assigned to the Scotch Village Formation. Their representation is poorly known from outcrop and they are not present in drill core although up to 100 m could be present in the triconed interval of drillhole 153-3 (Fig. 2-20). The Scotch Village Formation rock types were considered by Crosby (1962) and Stevenson (1959) to be part of the Riversdale Group. Howie and Barss (1975), however, reported a Pictou (Westphalian) spore assemblage from the Scotch Village Formation.

The interpretation of the geology of salt within the Shubenacadie-Stewiacke Valley is based upon diamond-drill core data (Table in Appendix I and Fig. 2-20) and associated geology (simplified in Fig. 2-17). Twenty holes are indicated as penetrating salt beds (Fig. 2-19) and of these only five have completely penetrated any of the beds. It is, therefore, apparent that the three dimensional aspects of the Stewiacke Formation are not rigorously definable as to thickness, distribution, and composition within the whole area. The incomplete intersections of the Stewiacke Formation, however, are useful in determining the minimum areal extent of the salt beds within the area.

The area along the southeastern border of the area is locally marked by varying degrees of disruption in post Carrolls Corner Formation strata. This may be interpreted as a disconformity paleokarst surface where anhydrite and possibly salt of the Stewiacke Formation were dissolved prior to the deposition of the MacDonald Road Formation. This surface could also be attributed in part to more recent solution collapse. Although the exact relationship between this feature and the faulting is not known, a surface of regional erosion (diastem) prior to the deposition of the MacDonald Road Formation may be the better explanation.

Stewiacke Formation

The Stewiacke Formation is the most important stratigraphic unit with respect to potential salt exploration or development. It is the thickest and most laterally extensive salt unit in the area and is the largest relatively undisturbed stratified salt deposit known in Nova Scotia (Type A, Fig. 1-11). The Stewiacke Formation is known from five deep drillhole intersections: 153-2, 153-1, SB-1, 153-3 and 153-4, located along the axis of the Shubenacadie Basin (Figs. 2-17, 2-18, and 2-19). A detailed correlation of the Windsor Group in these holes is presented in Figure 2-20.

The Stewiacke Formation comprises up to 300 m of banded medium- to coarse-grained halite (0.5 to 1.5 cm), with many thin interbeds of anhydrite and green halitic siltstone. No potash minerals are reported or indicated in the Formation.

The banding in the salt occurs as regular, but ill-defined layers 5 cm to 8 cm thick of alternating clear, pure, medium grained halite and smoky grey halite with finely dispersed anhydrite, organic and clay materials.

The anhydrite layers in the Stewiacke Formation range in thickness from 1 cm to 5 m, but may locally reach up to 20 m or more. They are grey and bluish to brownish grey, variably halitic and locally have borate mineral (danburite) porphyroblasts. Dips are typically gentle, and the thin layers observed in drill core are gently warped and locally dislocated into centimetre scale s-shaped minor folded fragments. No distinct structural fabric has been observed in the halite. The anhydrite layers are generally most common in the lower 1/2 to 2/3 of the section. The beds have no apparent distinctive characteristics and cannot be traced with confidence between the four drillhole sections which are, from west to east, approximately 9.5 km, 9.5 km, 11 km, and 12.5 km apart (Figs. 2-17, 2-20, 2-21, and 2-22).

Near the top of the salt, the insoluble interbeds consist predominantly of the grey-green laminated to massive siltstone with varying proportions of orangeish coloured halite porphyroblasts. The abundance of these layers increases upward in the section being most abundant in the upper 1/2 to 1/3 of the section. In some areas, substantially thick anhydrite beds, up to 20 m, occur in the upper parts of the Stewiacke Formation.

The Stewiacke Formation is probably in part a basinal facies equivalent to the upper part of the Carrolls Corner Formation. This facies relationship has not been defined in drilling, although it is suspected to occur as a narrow intertongued zone.

Salt Deposit Limits

Geological mapping combined with drillhole data indicate the Stewiacke Formation underlies an area 42 km to 50 km long and 6 km wide. This excludes the complex area near the northern border fault zone (Fig. 2-17). The maximum area underlain by the relatively undeformed Stewiacke Formation is inferred to be approximately 300 km^2. Thickness variations within the Stewiacke Formation are less well defined, due mainly to the lack of subsurface data in critical areas across the strike of the Shubenacadie Basin. In the axis of the Basin, the thickness reaches 300 m, but along the margin to the southeast, the Formation is not present. An average thickness of 75 m is calculated for the entire area. The volume of Stewiacke Formation within this block approximates 22.5 km^3 and this would contain approximately 50 Gt (billion tonnes) of rock (15 wt% insolubles).

The depth of the top of the Stewiacke Formation, in the axis of the Basin, reaches a maximum of approximately 555 m (1820 ft.) in drillhole 153-3, but generally lies between 300 and 350 m (985-1148 ft.) where the Watering Brook Formation is thin (Figs. 2-17 and 2-23). Around the perimeter of the Basin, the top of the salt should occur at depths of 100 to 200 m depending upon the remaining thickness of the MacDonald Road and Green Oaks Formations.

GEOPHYSICS

The major part of the Shubenacadie Basin is included on a Bouguer gravity anomaly map at a scale of two inches equals one mile. This map (simplified in Fig. 2-24) is based upon the Nova Scotia Research Foundation 11E/03 and 11E/04 gravity map sheets, with newer infill stations by St. Joseph Exploration. The gravity anomaly patterns within the Basin may be used to interpret the Stewiacke Formation thickness distribution in areas where subsurface data are not available. Cross-sections depicting geology and gravity profiles of several lines transverse to the structural strike (Figs. 2-17 and 2-24) are presented in Figure 2-25. The relationships and variation in the gravity appear to be determined mainly by known variations in the geology i.e. depth to salt, thickness of salt, and the nature of overlying and underlying strata. A differential of up to 20 mGal exists between the minima in the Basin centre and the maxima along the southern border of the Basin. The generally stratified nature and minimal structural disturbance together with good deep drillhole control make the Shubenacadie-Stewiacke deposit an excellent site for detailed quantitative gravity modelling.

Downhole geophysical logs including gamma ray, neutron, density and caliper logs are available for four of the deep holes, 153-1, 153-2, 153-3 and 153-4. These logs are useful in verifying lithologic identification and correlation. In the case of 153-1, which has detailed chemical analyses, a general assessment of grade may be possible. In the event of future exploration drilling, coring could be restricted to the Stewiacke Formation and eventually it may not be necessary to core at all if drilling proves the deposit to be as consistent as believed. In this case, geophysical logs could be used in partially cored or uncored (triconed) drillholes.

GEOCHEMISTRY

Two deep drillholes (SB-1 and 153-1) that penetrated the Stewiacke Formation were selected for detailed chemical analyses in order to assess the purity of the salt deposit (Figs. 2-17, 2-19, 2-20, 2-21, and 2-22). These salt sections, approximately 9.5 km apart, are representative of the Stewiacke Formation and two MacDonald Road Formation salt units.

The salt sections in the drillholes were logged in detail and the core split. Intervals of approximately 3 m (10 ft.) were bagged as bulk samples of continuous halved core. Continuous anhydrite sections more than 1 m thick were avoided in sampling, with intervals stopping at these units. Fortunately, these were not common and sampling is nearly continuous. Whole rock analyses were made at the Technical University of Nova Scotia, Laboratory for Investigation of Minerals, Halifax, Nova Scotia. The following major oxides and trace elements were analyzed (whole rock): Na_2O, CaO, MgO, K_2O, Fe_2O_3, SO_4, CO_3, Cl, Br, Rb, B and per cent insoluble. In addition, U_2O_3 analyses were done by Atomic Energy of Canada Limited in Ottawa. Major and minor oxide analyses and insoluble residue results together with calculated mineral components are presented in Appendix 2.

Preliminary assessment of the data using Br and Sr ratios together with K_2O analyses (whole rock) indicate a probable low degree of brine concentration and no indication of potash salt precipitation.

The Stewiacke Formation section samples in 153-1 (Table 2-5) have an average analysis of 86.79% NaCl and a total thickness of 315 m (1033 ft.). The same section in SB-1 has an average analysis of 88.16% NaCl and a total thickness of 272 m (892 ft.). The analyses indicate very few highly pure salt sections, but this is only an apparent feature if consideration is given to the sampling method and the mode of occurrence of the discrete, solid anhydrite layers within the continously sampled intervals. Chemical analyses and detailed core logging indicate the lower 30 to 60 m of the Stewiacke Formation are the salt section without significant anhydrite interbeds.

Cole (1930a) reported the occurrence of a salt spring near the northeastern end of the Stewiacke Valley. An analysis of a sample from the Otter Brook Spring (No. 36) is presented in Table 2-6. This spring has a high content of $CaSO_4$ indicating dissolution of gypsum or anhydrite in addition to halite.

ECONOMIC CONSIDERATIONS

Potash was not identified as an associate mineral in the halite deposit. The Shubenacadie-Stewiacke deposit is estimated to contain approximately 50 Gt (billion tonnes) of 85% NaCl. It is delineated by 5 deep and 14 shallower holes. The depth to salt ranges from 180 m up to 500 m in the deepest part of the basin. A large block of salt, up to 300 m thick, occurs in the centre of the area and has a length exceeding 40 km and an average width of 6 km. The salt is stratified and only slightly deformed except near the northwestern limits. Some faulting is apparent in the overlying rocks in the central part of the area, but this is believed to be of minor consequence. Chemical analyses indicate that the major Stewiacke Formation salt in two drillholes has an average grade of 86.79% and 88.16%, although significant sections have grades in excess of 90% and sometimes up to 94% NaCl (whole rock). The deposit's thickness, its relatively undisturbed nature, its great lateral extent and reasonable depth, and the virtual absence of salt springs, all favour use for the future development of mines and underground storage facilities. Although this deposit may be of economic value, it has not as yet been utilized.

STANLEY OCCURRENCE

LOCATION

The Stanley occurrence is located 5.6 km northwest of Stanley (NTS 11E/04W), Hants County (Figs. 1-4, 1-10 and 2-26). Stanley is located near the southern border of the Kennetcook River valley 7 km southwest of Clarksville and 19 km northeast of Windsor. The area is accessible by

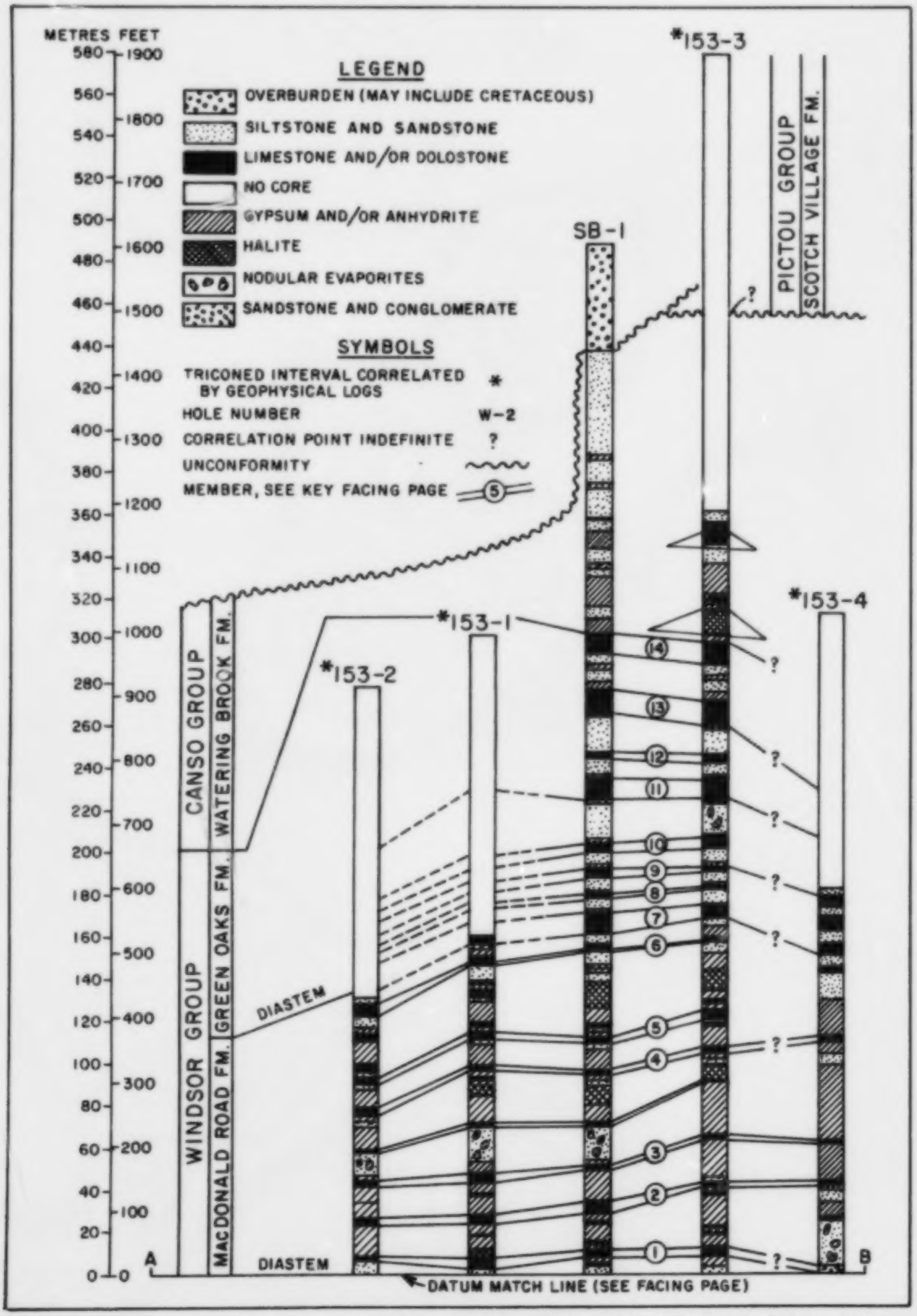

METRES
FEET
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
LEGEND
OVERBURDEN (MAY INCLUDE CRETACEOUS)
SILTSTONE AND SANDSTONE
LIMESTONE AND/OR DOLOSTONE
NO CORE
GYPSUM AND/OR ANHYDRITE
HALITE
NODULAR EVAPORITES
SANDSTONE AND CONGLOMERATE
SYMBOLS
TRICONED INTERVAL CORRELATED BY GEOPHYSICAL LOGS *
HOLE NUMBER W-2
CORRELATION POINT INDEFINITE ?
UNCONFORMITY
MEMBER, SEE KEY FACING PAGE ⑤
*153-3
SB-1
*153-4
*153-1
*153-2
PICTOU GROUP
SCOTCH VILLAGE FM.
CANSO GROUP
WATERING BROOK FM.
WINDSOR GROUP
GREEN OAKS FM.
MACDONALD ROAD FM.
DIASTEM
DIASTEM
A
B
⑭
⑬
⑫
⑪
⑩
⑨
⑧
⑦
⑥
⑤
④
③
②
①
?
DATUM MATCH LINE (SEE FACING PAGE)

Figure 2-20. Drillhole profiles and correlation, 153-2, 153-1, SB-1, 153-3 and 153-4, Shubenacadie-Stewiacke deposit. (For locations see Fig. 2-17).

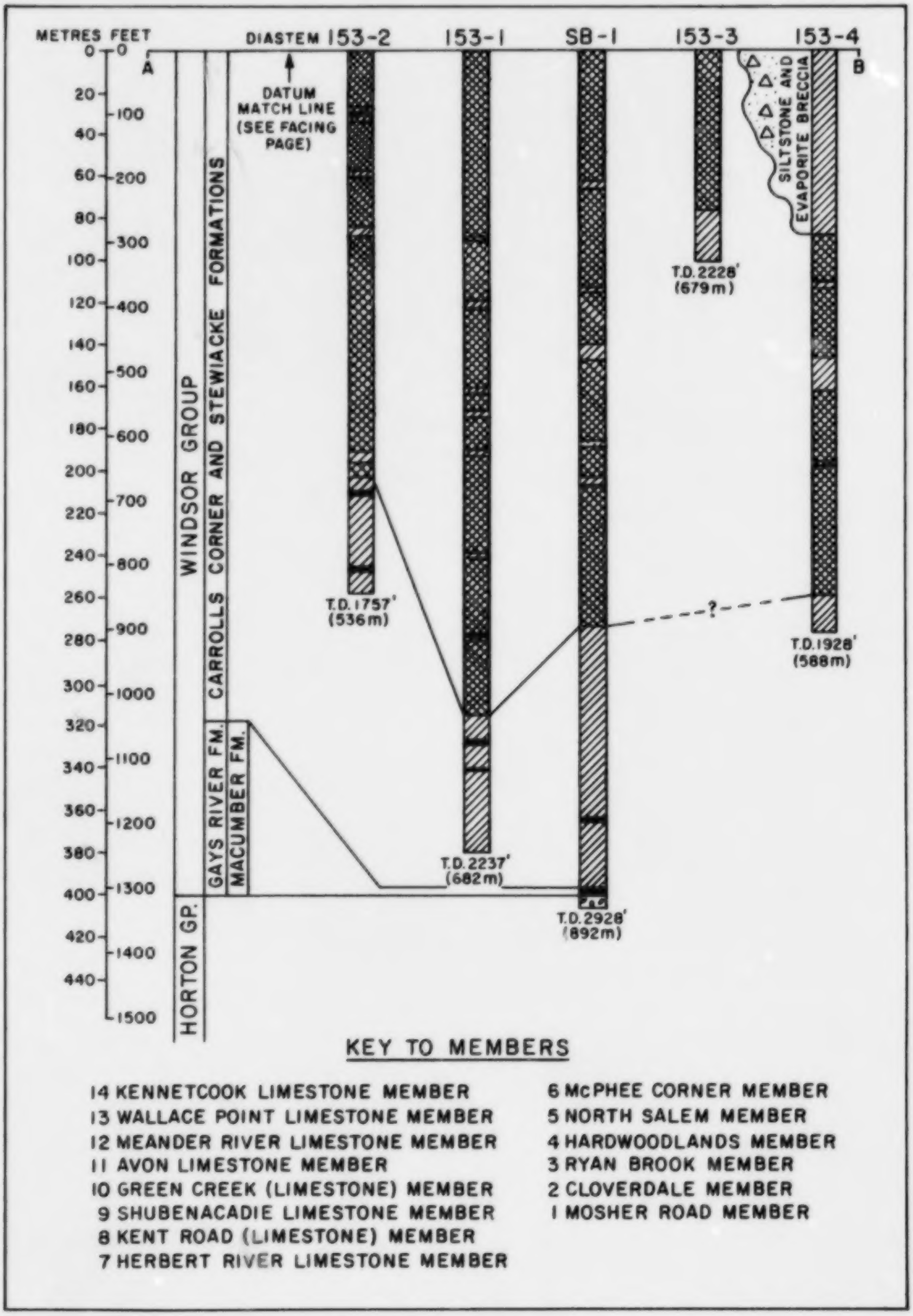
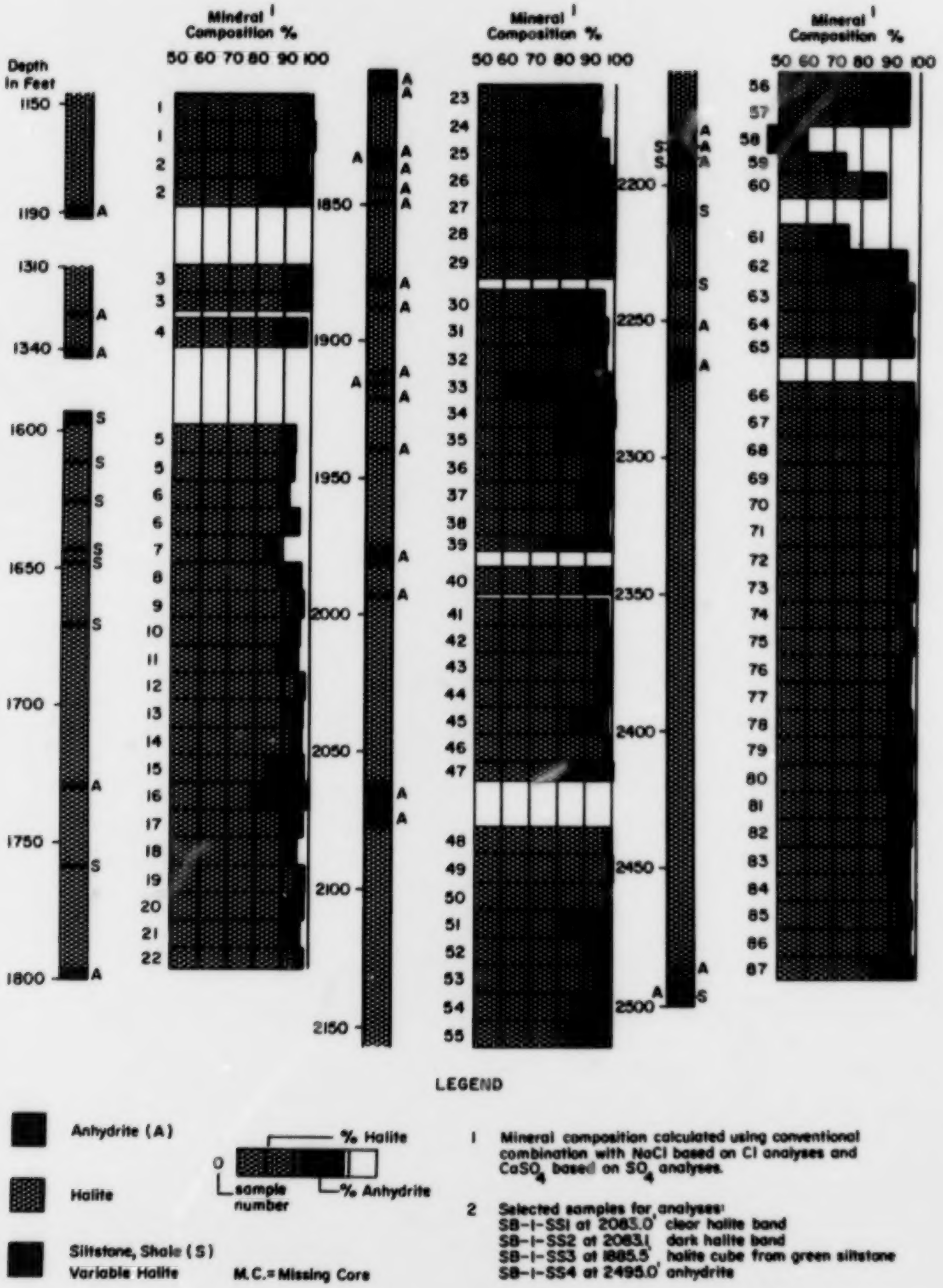

METRES FEET
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
A
B
DIASTEM
153-2
153-1
SB-1
153-3
153-4
DATUM MATCH LINE (SEE FACING PAGE)
WINDSOR GROUP
CARROLLS CORNER AND STEWIACKE FORMATIONS
GAYS RIVER FM.
MACUMBER FM.
HORTON GP.
SILTSTONE AND EVAPORITE BRECCIA
T.D. 1757' (536m)
T.D. 2237' (682m)
T.D. 2928' (892m)
T.D. 2228' (679m)
T.D. 1928' (588m)
?
KEY TO MEMBERS
14 KENNETCOOK LIMESTONE MEMBER
13 WALLACE POINT LIMESTONE MEMBER
12 MEANDER RIVER LIMESTONE MEMBER
11 AVON LIMESTONE MEMBER
10 GREEN CREEK (LIMESTONE) MEMBER
9 SHUBENACADIE LIMESTONE MEMBER
8 KENT ROAD (LIMESTONE) MEMBER
7 HERBERT RIVER LIMESTONE MEMBER
6 McPHEE CORNER MEMBER
5 NORTH SALEM MEMBER
4 HARDWOODLANDS MEMBER
3 RYAN BROOK MEMBER
2 CLOVERDALE MEMBER
1 MOSHER ROAD MEMBER

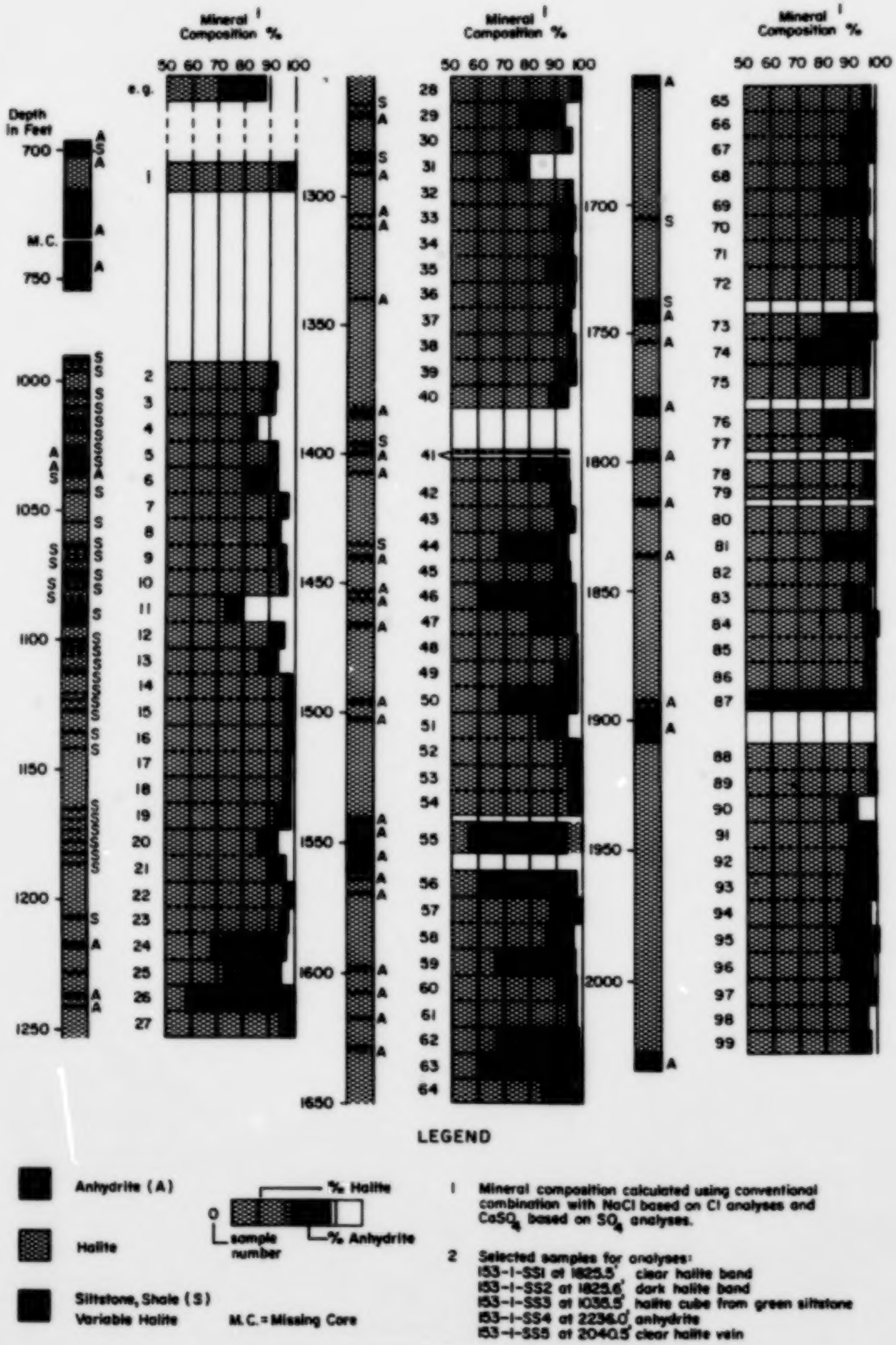
Figure 2-20. Continued.



1 Mineral composition calculated using conventional combination with NaCl based on Cl analyses and $CaSO_4$ based on SO_4 analyses.

2 Selected samples for analyses:
SB-I-SSI at 2083.0' clear halite band
SB-I-SS2 at 2083.1' dark halite band
SB-I-SS3 at 1885.5' halite cube from green siltstone
SB-I-SS4 at 2495.0' anhydrite

Figure 2-21. Detailed profile of salt sections in drillhole SB-1, Shubenacadie-Stewiacke deposit.



1 Mineral composition calculated using conventional combination with NaCl based on Cl analyses and $CaSO_4$ based on SO_4 analyses.

2 Selected samples for analyses:
153-1-SS1 at 1825.5' clear halite band
153-1-SS2 at 1825.6' dark halite band
153-1-SS3 at 1036.5' halite cube from green siltstone
153-1-SS4 at 2236.0' anhydrite
153-1-SS5 at 2040.5' clear halite vein

Figure 2-22. Detailed profile of salt sections in drillhole 153-1, Shubenacadie-Stewiacke deposit.

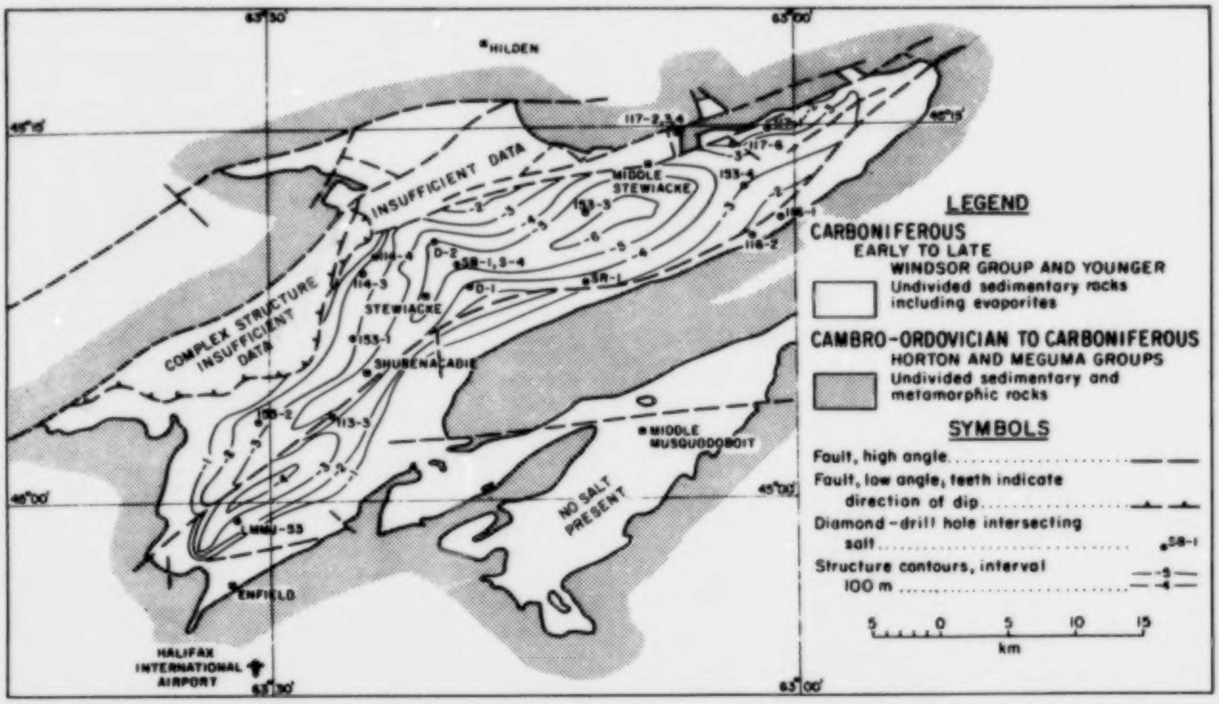

63°30'
63°00'
HILDEN
45°15'
45°00'
INSUFFICIENT DATA
COMPLEX STRUCTURE INSUFFICIENT DATA
MIDDLE STEWIACKE
STEWIACKE
SHUBENACADIE
MIDDLE MUSQUODOBOIT
NO SALT PRESENT
ENFIELD
HALIFAX INTERNATIONAL AIRPORT
LMMJ-53
117-2,3,4
117-6
153-4
153-3
116-1
116-2
114-4
114-3
D-2
D-1
SB-1,3-4
SR-1
153-1
153-2
113-3
LEGEND
CARBONIFEROUS
EARLY TO LATE
WINDSOR GROUP AND YOUNGER
Undivided sedimentary rocks including evaporites
CAMBRO-ORDOVICIAN TO CARBONIFEROUS
HORTON AND MEGUMA GROUPS
Undivided sedimentary and metamorphic rocks
SYMBOLS
Fault, high angle
Fault, low angle, teeth indicate direction of dip
Diamond-drill hole intersecting salt
SB-1
Structure contours, interval 100 m
-5
-4
5 0 5 10 15
km

Figure 2-23. Structural contour map, Stewiacke Formation salt, Shubenacadie-Stewiacke deposit.

63°30'
63°00'
45°15'
45°00'
MIDDLE STEWIACKE
STEWIACKE
SHUBENACADIE
MIDDLE MUSQUODOBOIT
ENFIELD
HALIFAX INTERNATIONAL AIRPORT
LMMJ-53
117-2,3,4
117-1
117-6
153-4
153-3
114-4
114-3
D-2
D-1
SB-1,3-4
SR-1
153-1
153-2
113-3
0 5 10 15 km
Bouguer gravity after St. Joseph Exploration and the Nova Scotia Research Foundation (1966a)
LEGEND
CARBONIFEROUS
WINDSOR GROUP AND YOUNGER
Undivided sedimentary rocks including evaporites.
CAMBRO-ORDOVICIAN TO CARBONIFEROUS
MEGUMA AND HORTON GROUPS
Undivided sedimentary and metamorphic rocks.
SYMBOLS
Diamond-drill hole intersecting salt
S-4
Geological-Bouguer gravity cross-section (Fig 2-25)
D
D1
CONTOUR INTERVAL: 1 mGal
(980,6) 33.00 mGal
(980,6) 34.00 mGal
Minima and maxima

Figure 2-24. Bouguer gravity anomaly map, Shubenacadie-Stewiacke deposit.

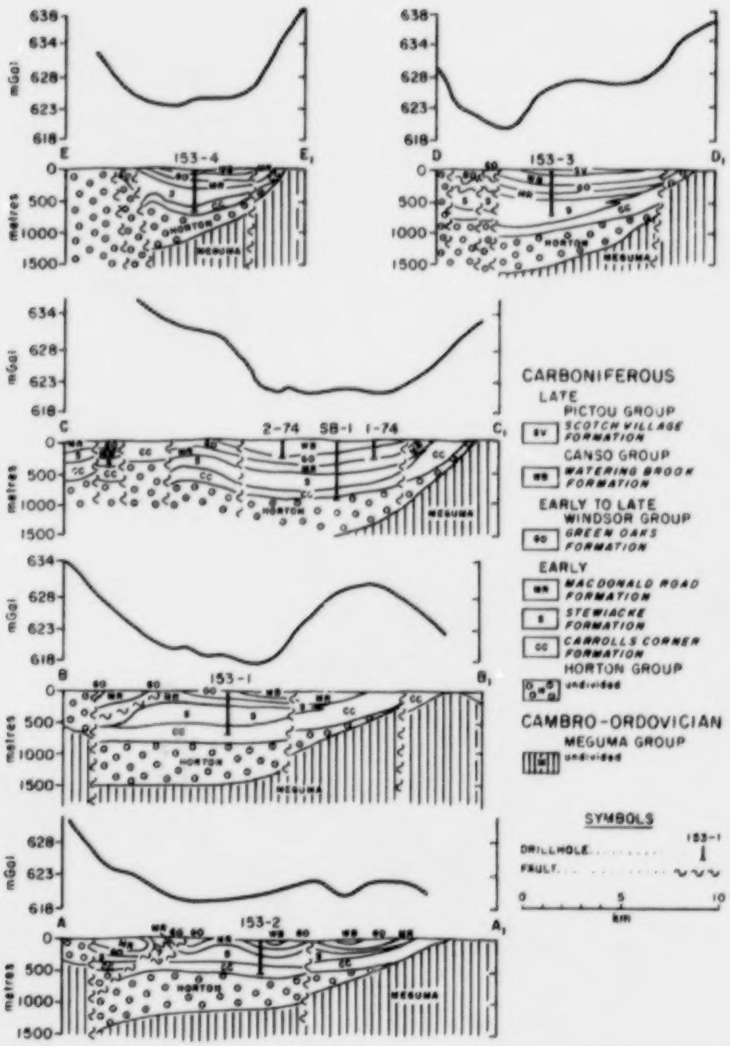

638
634
628
623
618
mGal
E
153-4
E1
0
500
1000
1500
metres
HORTON
MEGUMA
D
153-3
D1
C
2-74
SB-1
1-74
C1
B
153-1
B1
A
153-2
A1
CARBONIFEROUS
LATE
PICTOU GROUP
SV
SCOTCH VILLAGE FORMATION
CANSO GROUP
WB
WATERING BROOK FORMATION
EARLY TO LATE
WINDSOR GROUP
GO
GREEN OAKS FORMATION
EARLY
MR
MACDONALD ROAD FORMATION
S
STEWIACKE FORMATION
CC
CARROLLS CORNER FORMATION
HORTON GROUP
undivided
CAMBRO-ORDOVICIAN
MEGUMA GROUP
undivided
SYMBOLS
DRILLHOLE
153-1
FAULT
0
5
10
km

Figure 2-25. Schematic geological and Bouguer gravity cross-sections, Shubenacadie-Stewiacke deposit, Hants and Colchester Counties.

unpaved and bush roads extending from Highway 236 that runs through Stanley from Windsor to South Maitland.

Stanley lies within the central part of the Carboniferous Lowlands of north-central Hants County. This area is characterized by very gently undulating hills with elevations rarely exceeding 50 m in generally marshy terrain. The area is bordered on the south by the Rawdon Hills Highlands where elevations rise up to 150 m and locally exceed 200 m.

HISTORICAL BACKGROUND

The Stanley occurrence is located within the Windsor Basin of Hayes (1931), who assessed the area's potential for potash as part of a regional investigation. Many salt springs indicative of the presence of salt were located. The Stanley area occurs in the western extremity of the Kennetcook map area (Stevenson, 1959) which adjoins the Wolfville map area (21H/01) mapped by Crosby (1962) and the Londonderry, Bass River map areas (11E/05) to the north mapped by Weeks (1948).

In 1966 Scurry-Rainbow Oil Limited explored the area as part of a Province wide exploration program for sulphur possibly associated with Windsor Group evaporites. A gravity survey by the Nova Scotia Research Foundation outlined a Bouguer gravity high and a Bouguer gravity low centred approximately 5.6 km north-northwest of Stanley. Two exploratory boreholes were drilled on the gravity low, one of which penetrated salt.

GEOLOGY

The geology in the immediate area of the Stanley occurrence is not well known. Most of the area

Table 2-5. Summary of salt grades and intervals from drillholes 153-1 and SB-1, Shubenacadie-Stewiacke deposit.

Sample Numbers	Per cent NaCl	Thickness Feet	Thickness Metres	Interval Feet	Interval Metres
Drillhole 153-1					
153-14-19	94.87	60.0	18.2	1113.0-1173.0	339.3-357.5
153-21-23	93.58	30.0	9.1	1183.0-1213.0	360.6-369.7
153-27-39	89.79	130.0	39.6	1243.0-1373.0	378.9-418.5
153-65-72	89.20	83.2	25.4	1653.8-1737.0	504.1-529.5
153-75-86	90.48	126.1	38.4	1762.0-1888.1	537.1-575.5
153-75-89	91.46	166.5	50.7	1762.0-1928.5	537.1-587.8
Drillhole SB-1					
SB-09-14	92.13	60.0	18.3	1658.0-1718.0	505.3-523.6
SB-17-22	92.16	57.7	17.6	1738.1-1795.7	529.8-547.4
SB-41-46	93.72	60.0	18.2	1993.5-2053.5	607.6-625.8
SB-48-53	93.70	60.0	18.2	2077.5-2137.5	633.2-641.4
SB-66-78	94.31	130.0	39.6	2271.8-2401.8	692.4-732.0
SB-66-86	92.95	210.0	64.0	2271.8-2481.8	692.4-756.4

is underlain by nearly flat lying rocks assigned to the Scotch Village Formation (Stevenson, 1959). Outcrops are few and the underlying Windsor Group is rarely present, except 3 km to the west of SR5-3 where a small karst area with a salt spring occurs. Wright (1931) reported the occurrence of two salt springs in the vicinity of the Stanley occurrence as follows: Spring No. 1 "... on the west side of the Deal Road about 300 yards south of Four Mile Brook (about 4.25 miles) in a straight line southeasterly from Walton... A 'Deer Lick' with a trickly of brackish water- ...Odour of hydrogen sulphide..." Spring No. 2 is reported to be located 1/4 mile northwest of Pinnacle Hill and one mile south of Spring No. 1. It is a salty seep with no appreciable flow.

The stratigraphy in the area is known only from boreholes drilled by Scurry-Rainbow Oil Ltd (Fig. 2-27). The section of rocks encountered was described from chips, making detailed stratigraphic or structural interpretations tenuous. The recovery of soft highly soluble minerals including salt and potash is especially difficult. The Scotch Village Formation unit mapped in the area appears to be well represented in the drilling, occurring as a thick sequence of red shale with grey sandstone. Drillhole SR5-1, 5 km north of SR5-3, intersected 425 m (1400 ft.) of this sequence apparently without reaching the Windsor Group. This thickness is comparable to the thicknesses intersected in the drillholes at the Walton occurrence to the north. This sequence probably unconformably overlies the highly deformed Windsor Group. This succession comprises interstratified red siltstone, gypsum, anhydrite, and limestone in the lower parts of SR5-2 and most of SR5-3 boreholes. Salt was intersected at a depth of 350 m (1150 ft.) in SR5-3, which was abandoned in salt at 366 m (1200

Table 2-6. Chemical analyses, Otter Brook Spring, Shubenacadie-Stewiacke deposit.*

Spring Sample No.		**36**
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atomsphere, °F .		n.d
Temperature of brine, °F		n.d
Baume degrees		n.d
Equivalent specific gravity ...		
LABORATORY NOTES		
Specific gravity at 60°F		1.0033
Total solids at 110°C		0.60
Reaction		N
ANALYSES OF SOLIDS		
Na	Per cent	18.64
K	Per cent	n.d.
Ca	Per cent	12.33
Mg	Per cent	0.27
SO_4	Per cent	29.12
Cl	Per cent	29.38
Br	Per cent	n.d.
I	Per cent	n.d.
Totals		89.74
HYPOTHETICAL COMBINATION		
$CaSO_4$	Per cent	41.25
$CaCl_2$	Per cent	
$MgSO_4$	Per cent	0.25
$MgCl_2$	Per cent	0.86
K_2SO_4	Per cent	
KCl	Per cent	
Na_2SO_4	Per cent	
NaCl	Per cent	47.38
Totals		89.74

* Cole (1930a)

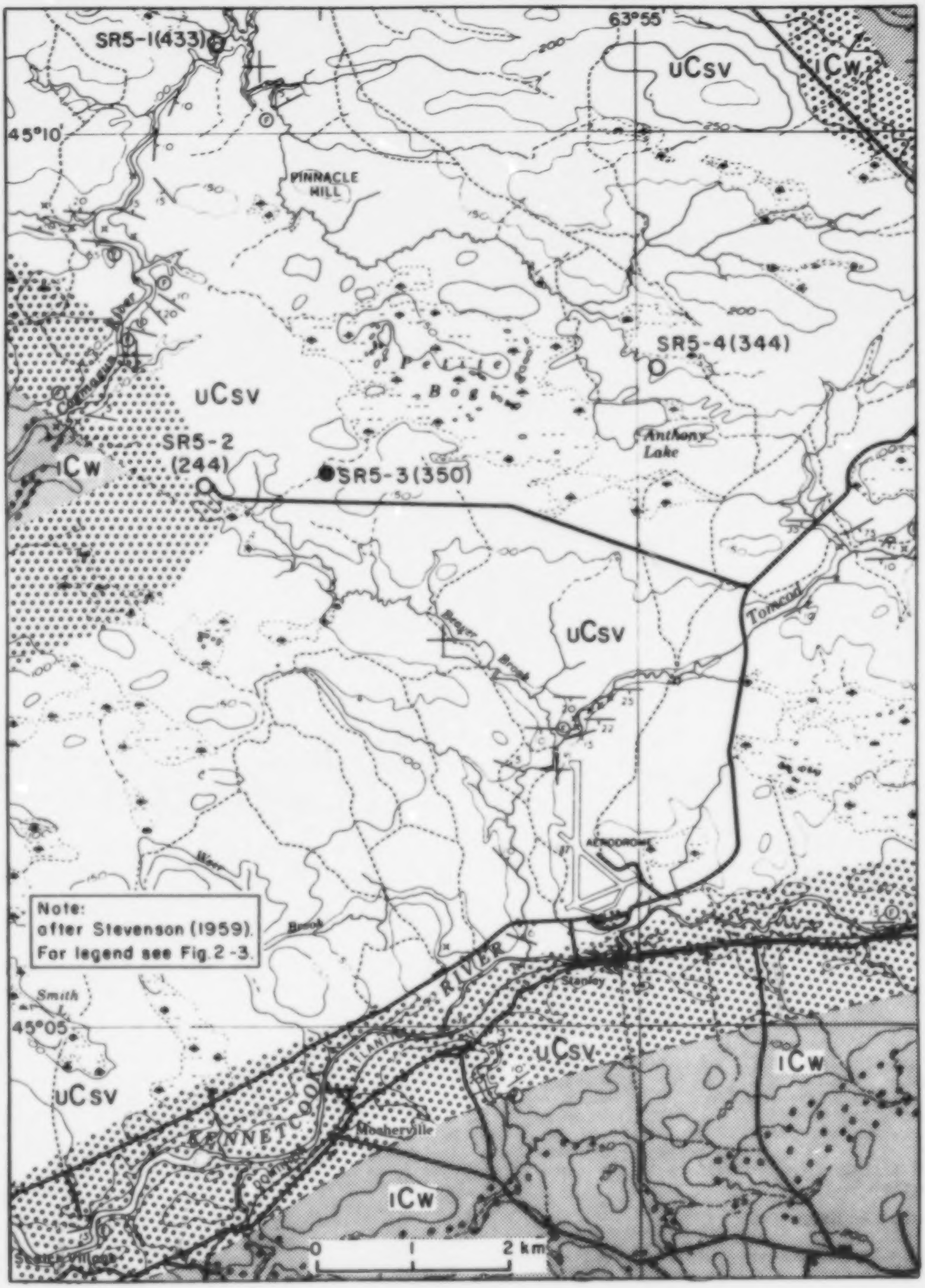
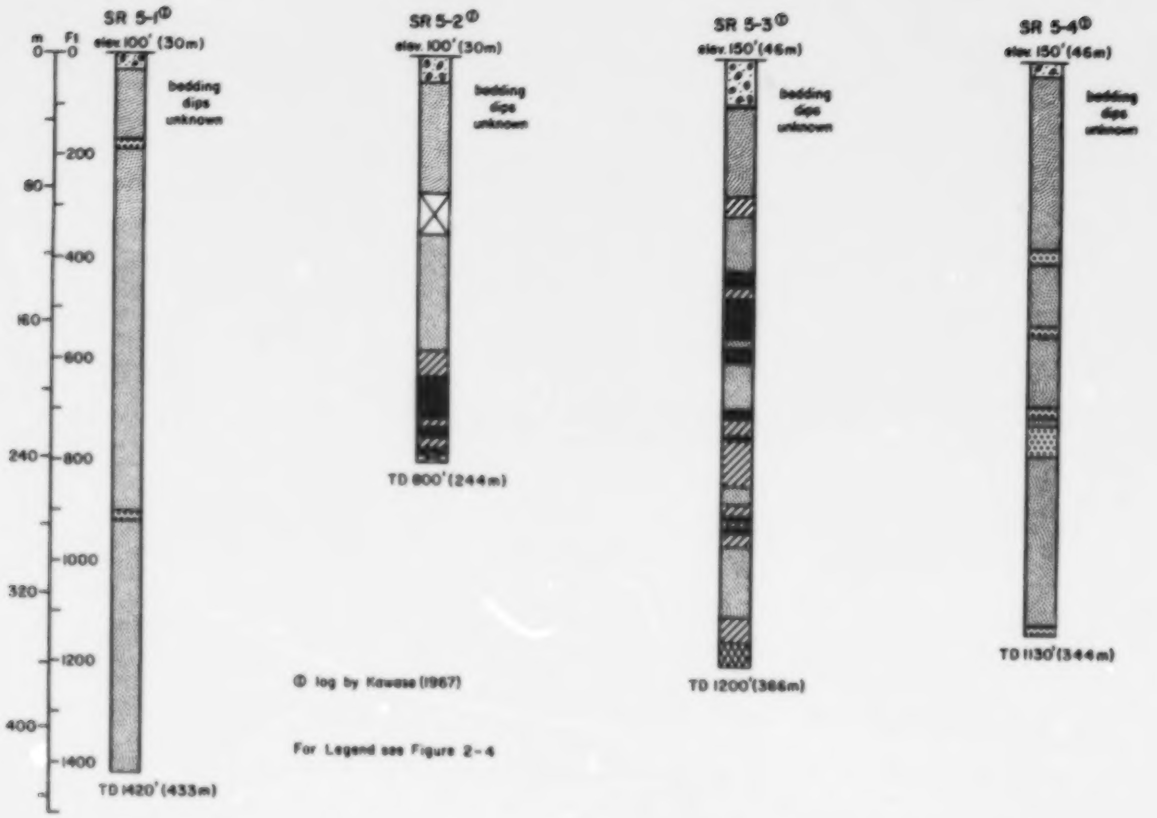

63°55'
SR5-1(433)
uCsv
lCw
45°10'
PINNACLE HILL
200
250
150
SR5-4(344)
Petite Bog
Anthony Lake
uCsv
SR5-2 (244)
SR5-3(350)
lCw
Tomcod
uCsv
Bergin Brook
AERODROME
Wier Brook
Note:
after Stevenson (1959).
For legend see Fig.2-3.
RIVER
Stanley
Smith L.
45°05'
uCsv
lCw
uCsv
KENNETCOOK
Mosherville
lCw
0
1
2 km
Scotch Village

Figure 2-26. Geology in the vicinity of the Stanley occurrence, Hants County.


m
Ft
0
0
200
80
400
160
600
240
800
1000
320
1200
400
1400
SR 5-1①
elev.100' (30m)
bedding dips unknown
TD 1420' (433m)
SR 5-2①
elev.100' (30m)
bedding dips unknown
TD 800' (244m)
SR 5-3①
elev.150' (46m)
bedding dips unknown
TD 1200' (366m)
SR 5-4①
elev.150' (46m)
bedding dips unknown
TD 1130' (344m)

① log by Kawase (1967)

For Legend see Figure 2-4

Figure 2-27. Drillhole profiles, Stanley occurrence. (For locations see Fig. 2-26).

ft.). The interstratified sequence above the salt in this borehole is typical of the cyclic B Subzone of the Lower Windsor and/or Upper Windsor units. Since the structural configuration in the area is not readily determinable, it is difficult to assess the nature of the salt occurrence. A large mass of salt may be present at depth, but its presence may only be confirmed by deep drilling.

GEOPHYSICS

The area in the vicinity of the Stanley occurrence is included in the Nova Scotia Research Foundation Bouguer Anomaly map 11E/4, Stanley, Hants County (Fig. 2-28). The major features on the map are a roughly triangular outlined minimum at 613.00 mGal, between adjacent highs of 622.00 mGal to the southwest and northeast. Cross-section C-C$_1$ (Fig. 2-28) indicates the Windsor Group salt is closest to the surface and possibly thicker towards the centre of the low and at a greater depth beneath Scotch Village Formation strata in the areas of the maxima.

ECONOMIC CONSIDERATIONS

The Stanley occurrence comprises halite, but since it is known only from borehole chips, potash could be present. The area is not readily accessible to tidewater shipping facilities. The salt was intersected in a single borehole SR5-3 at a depth of 350 m (1150 ft.). The hole was abandoned at 366 m (1200 ft.) in salt. The structural configuration, lateral extent and quality of the salt cannot be determined without additional drilling. Based on available data the deposit is not considered to be of economic importance.

SUMMERVILLE OCCURRENCE

The Summerville occurrence is located in the community of Summerville, western Hants County, (NTS 21H/01) (Figs. 1-4, 1-10 and 2-29) located on the eastern shore of the Avon River estuary 13 km north of Windsor and 3 km north of Hantsport.

The area is readily accessible by paved Highway 15 from Windsor. The tidewater port of Hantsport is located on the opposite shore of the Avon River estuary 3 km to the south.

The terrain is typical of the Carboniferous Lowlands with gently undulating hills with elevations rarely exceeding 75 m and poorly drained marshy areas common.

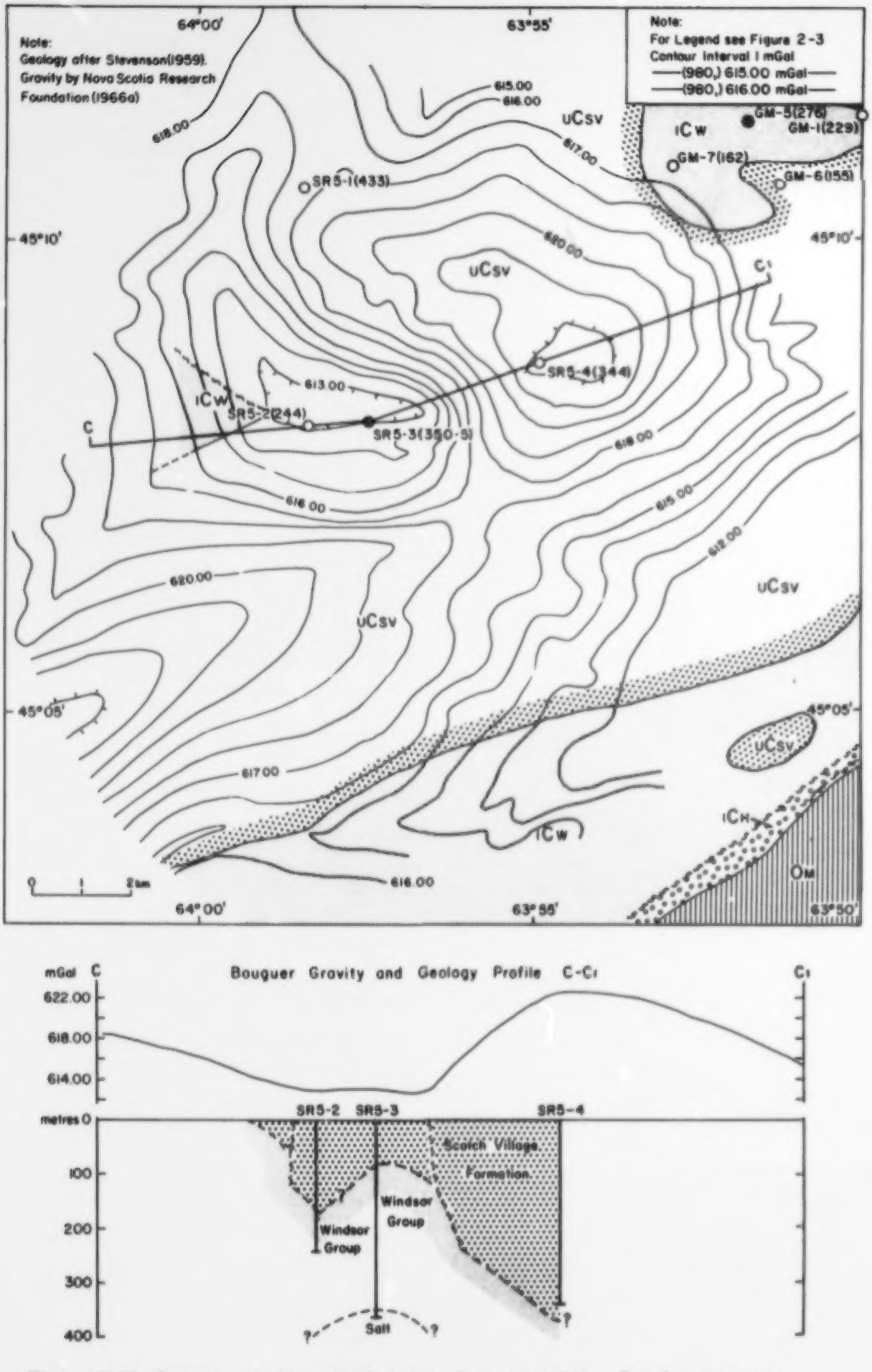

Note:
Geology after Stevenson(1959).
Gravity by Nova Scotia Research Foundation (1966a)
Note:
For Legend see Figure 2-3
Contour interval 1 mGal
(980,) 615.00 mGal
(980,) 616.00 mGal
64°00'
63°55'
63°50'
45°10'
45°05'
615.00
616.00
617.00
618.00
620.00
613.00
612.00
uCsv
lCw
lCH
OM
GM-5(276)
GM-1(229)
GM-7(162)
GM-6(155)
SR5-1(433)
SR5-2(244)
SR5-3(350.5)
SR5-4(344)
C
C1
0 1 2km
Bouguer Gravity and Geology Profile C-C1
mGal
622.00
618.00
614.00
metres 0
100
200
300
400
SR5-2
SR5-3
SR5-4
Scotch Village Formation
Windsor Group
Windsor Group
Salt
?

Figure 2-28. Bouguer gravity anomaly map and cross-section, Stanley occurrence.

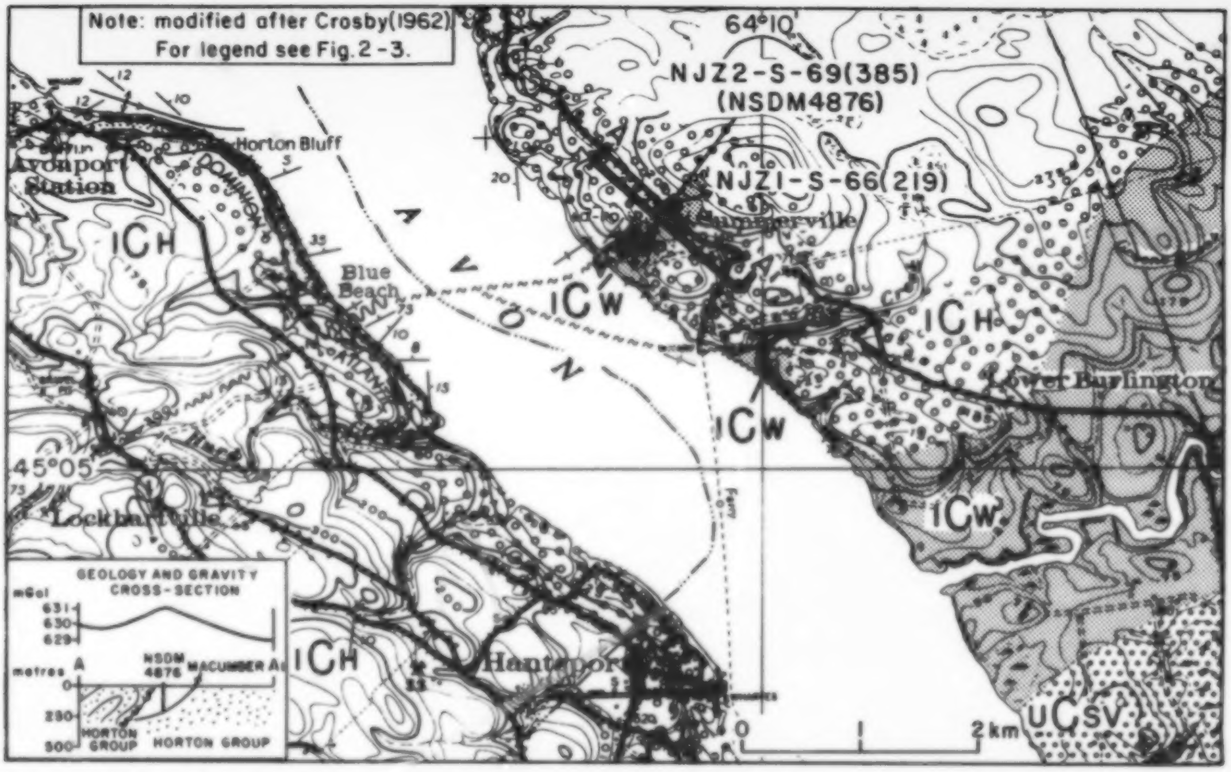

Note: modified after Crosby(1962)
For legend see Fig. 2-3.
64°10'
NJZ2-S-69(385)
(NSDM4876)
NJZ1-S-66(219)
Summerville
Horton Bluff
Avonport Station
DOMINION
lCH
Blue Beach
AVON
lCW
lCH
Lower Burlington
lCW
45°05'
Lockhartville
lCW
GEOLOGY AND GRAVITY CROSS-SECTION
mGal
631
630
629
metres
A
0
250
500
NSDM 4876
MACUMBER
A'
HORTON GROUP
HORTON GROUP
lCH
Hantsport
0
1
2 km
uCSV

Figure 2-29. Geological map of the Summerville occurrence, Hants County.

LOCATION

The Summerville occurrence is located within the Windsor Basin. It was investigated for its potash potential by Wright (1931) as part of a regional investigation by Hayes (1931). Many salt springs were located in the central part of the area to the east of Summerville and salt brines were encountered in Horton Group sandstones in an oil well boring at Cheverie 6.4 km to the north. No salt springs were located, however, in the immediate area of Summerville.

HISTORICAL BACKGROUND

In 1969 the area was explored for possible base metal deposits by New Jersey Zinc Exploration Company (Canada) Ltd. A diamond-drill hole, NJZ2-S-69 (NSDM 4876), was drilled on a small fault block of Windsor Group consisting mainly of Lower Windsor gypsum and anhydrite. A thick section of gypsum and anhydrite (with minor quantities of salt) overlying basal Windsor Macumber Formation and Horton Group were intersected. New Jersey Zinc Exploration Company Ltd. had drilled a hole, NJZ1-S-66, in 1966 to a depth of 220 m (720 ft.) in the anhydrite unit without intersecting salt.

GEOLOGY

The geology, as mapped by Crosby (1962), indicates the Windsor Group rocks occur as a small outlying fault block (Fig. 2-29). Bell (1929), reported that this fault (an extension of the Blue Beach Fault) had reverse movement with the Windsor Group gypsum underlying black shales of the Horton Group. Karst topography and gypsum outcrops and the adjacent quarry indicate much of the area is underlain by gypsum and anhydrite. The Horton Group rocks outcropping on the northern side of the fault are steeply dipping and locally overturned. Blanchard (1957) reported that gravity data suggested a northerly dipping fault at an angle between 45° and 75°. The nature of the southern contact with the Horton is not clearly discernible from the map but appears to be concordant. The NJZ2-S-69 drill-hole is located near the northeastern extremity of the block and penetrated 12.8 m (42 ft.) of gypsum (surficial hydration of anhydrite); 415.1 m (1362 ft.) of anhydrite (dip ranging from 30°-45°); 1.8 m (6 ft.) of basal Windsor, Macumber Formation limestone; and 5.2 m (17 ft.) of Horton Group (Figs. 2-29 and 2-30). Minor amounts of salt were logged in several intervals in the lower part of the thick anhydrite. Minor salt was found in the 380.0-388.2 m (1247-1274 ft.) interval (especially 384.9-385.1 m).

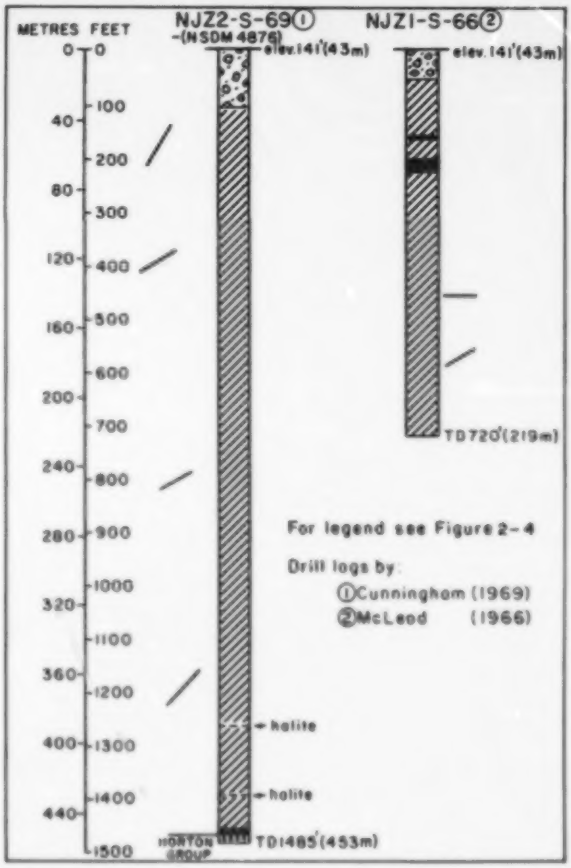


Figure 2-30. Drillhole profiles, Summerville occurrence, Hants County. (For locations see Fig. 2-29)

Salt was logged with anhydrite and gypsum between 413.9 and 424.4 m (1358 and 1392 ft.), and also between 424.4 and 425.6 m (1392 ft. and 1396 ft.) (especially at 425.1 m).

The area in the vicinity of the Summerville occurrence is included on the Nova Scotia Research Foundation Bouguer anomaly map 21H/01E (Fig. 2-13). In addition, there is a Nova Scotia Research Foundation total gravity map for the area (NSDME Open File Report 330). A Bouguer gravity high (Fig. 2-13) is coincident with the Windsor Group outcrop area and is apparently due to the high density of the anhydrite and the absence of significant quantities of salt. The exact mode of salt occurrence is not described in the drill log. It is inferred to occur as either inclusions, thin beds or veins.

ECONOMIC CONSIDERATIONS

At Summerville salt occurs in minor amounts in several intervals of anhydrite (basal anhydrite, part of the Vinland Formation of Moore and Ryan, 1976, Fig. 2-1). This salt probably occurs as minor inclusions or veins with very limited lateral extent and is not likely to occur in economically significant quantities. Potash was not found in this area. The occurrence is not considered to be of economic importance.

UPPER WALTON RIVER OCCURRENCE

LOCATION

The Upper Walton River occurrence is located approximately 13 km southeast of Walton (NTS 11E/04W), Hants County (Figs. 1-4, 1-10 and 2-31). The area is not readily accessible and can only be reached by unpaved roads and trails. The terrain is typical of the Carboniferous Lowlands with very gently undulating hills, with elevations that rarely exceed 75 m. The area is locally marshy making access difficult.

HISTORICAL BACKGROUND

The Upper Walton River area was investigated for its potash potential by Wright (1931) as part of a regional investigation by Hayes. Several salt springs were located in the area indicating the leaching of salt at depth. The area was mapped by Stevenson (1959). Many salt springs and a single lead showing were located in the vicinty. The area has been explored for base metal mineralization by a number of companies two of which undertook diamond drilling. In 1969 Magnet Cove Barium Corporation (Dresser Minerals) drilled several deep holes in the area. The WR-1 borehole was drilled slightly south of the lead showing. It was abandoned at a total depth 609 m (2000 ft.) with salt first reported at 344.4 m (1130 ft) The log of this borehole is rather sketchy, so the nature and quantity of salt indicated from approximately 344 to 609 m is uncertain.

A second hole, EMCO #2, drilled approximately 5 km to the northwest of the main occurrence area, also has a very general log that indicated possible salt in a zone of lost core between 331 and 364 m (1086 and 1194 ft.).

In 1975 the area was explored for base metal deposits by Gulf Minerals Canada. A series of eight holes were drilled (Fig. 2-32). The deepest, GM-5, penetrated salt from 276.8 m to 287.4 m (908-943 ft.) before it was abandoned in the salt. The GM-5 hole was drilled approximately 1.5 km south of WR-1.

GEOLOGY

The geology in the vicinity of the Upper Walton River occurrence was mapped by Stevenson (1959) (Fig. 2-31). The occurrence is located in an area underlain by a Windsor Group outlier

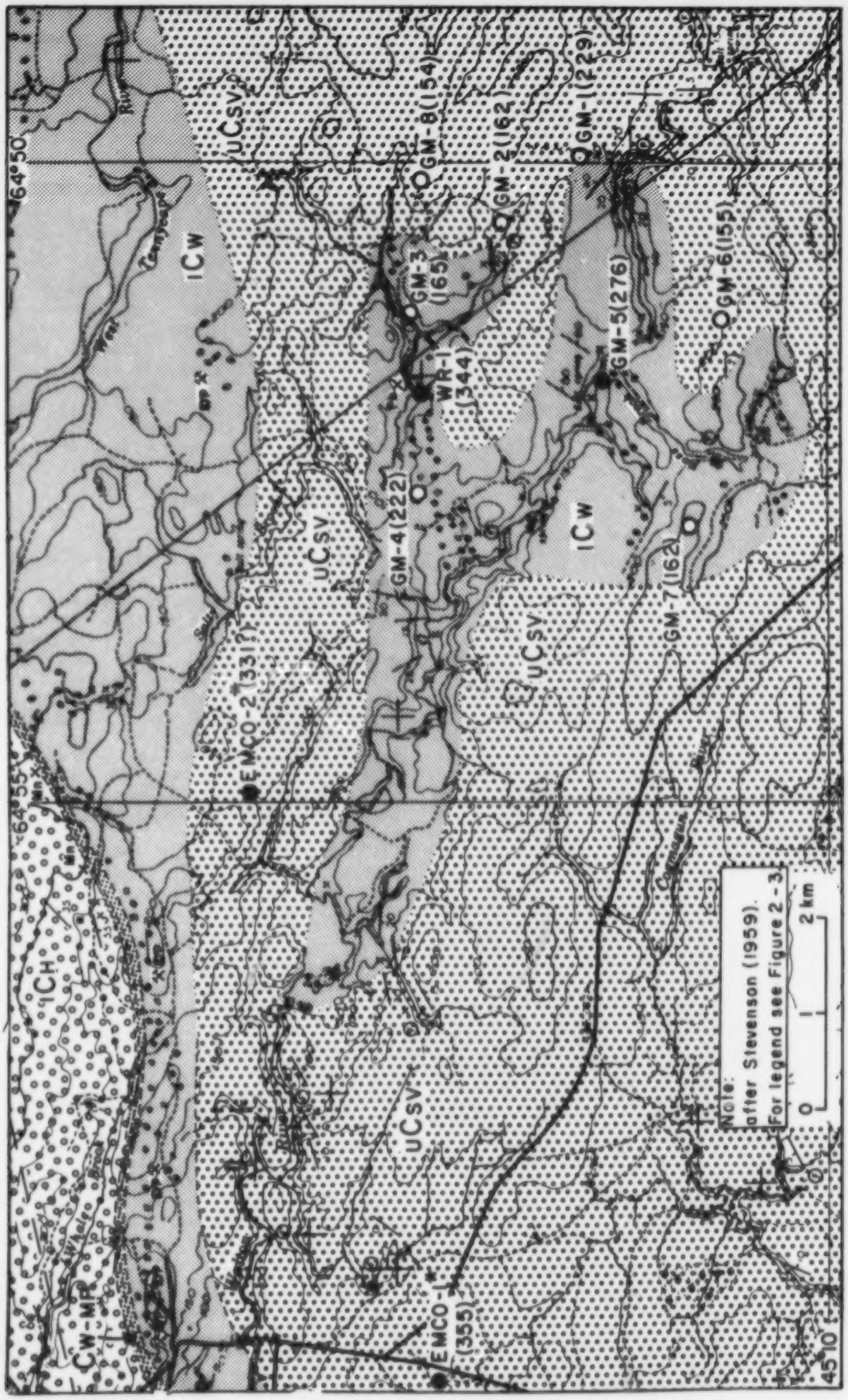
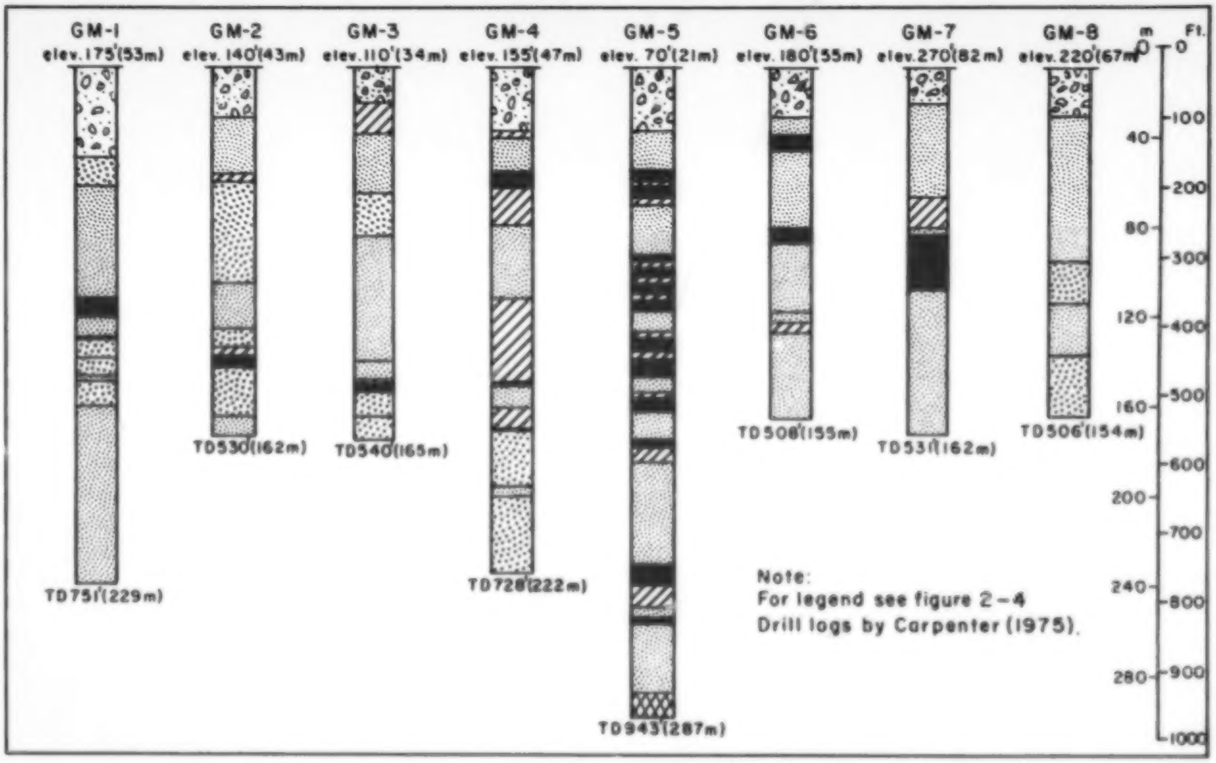

64°50'
64°55'
45°10'
lCH
CW-MR
lCw
uCsv
GM-8(154)
GM-2(162)
GM-1(229)
GM-3 (165)
WR-1 (344)
GM-5(276)
GM-6(155)
GM-4(222)
GM-7(162)
EMCO-2 (331?)
EMCO (355)
Note:
after Stevenson (1959).
For legend see Figure 2-3
0 1 2 km

Figure 2-31. Geology in the vicinity of the Upper Walton River occurrence, Hants County.


GM-1
elev.175'(53m)
GM-2
elev. 140'(43m)
GM-3
elev.110'(34m)
GM-4
elev.155'(47m)
GM-5
elev. 70'(21m)
GM-6
elev.180'(55m)
GM-7
elev.270'(82m)
GM-8
elev.220'(67m)
m
Ft.
TD751'(229m)
TD530'(162m)
TD540'(165m)
TD728'(222m)
TD943'(287m)
TD508'(155m)
TD531'(162m)
TD506'(154m)
0
40
80
120
160
200
240
280
0
100
200
300
400
500
600
700
800
900
1000

Note:
For legend see figure 2-4
Drill logs by Carpenter (1975).

Figure 2-32. Drillhole profiles, Upper Walton River occurrence.

surrounded by relatively flat lying strata assigned to the Scotch Village Formation. The northern limit of the Windsor Group outcrop is marked by the basal Windsor, Macumber Formation limestone, and Pembroke Formation conglomerate which lie with apparent conformity on the Horton Group comprising sandstone, shale and minor conglomerate. Karst topography, salt springs and irregular (bedding) attitudes were observed by Stevenson (1959).

Wright (1931) reported the occurrence of a salt spring on the southern bank of the Walton River 2 km upstream from where the Walton Woods Road crosses. The occurrence is reported to be a "small trickle" from Scotch Village red shales and sandstone. Analyses of these springs are not reported.

The detailed stratigraphy of the carbonate units in the GM-5 drillhole (Figs. 2-33 and 2-34) was studied by Boehner (1977c), who described the presence of multiple repetition of a single unit (B Subzone?) from faulting and isoclinal recumbent folding.

The detailed correlation of the 12 structurally repeated sections of the same carbonate unit are presented as a series of detailed pictorial logs in Figure 2-33 The sections have been plotted on an arbitrary datum (assumed stratigraphic base). In many instances the interval between the sections is continuous as is indicated by the drillhole depths indicated beside the column (ie. sections 5-6, 7-8-9-10, and 11-12). Repetition by isoclinal folding in these intervals is documented by the inversion of the distinctive subunits A-E. A schematic interpretation of the structural repetition in drillhole GM-5 is presented in Figure 2-34. This type of structure has been described in the Windsor area by Geldsetzer et al. (1980) as being related to gravity slide tectonism.

The complex structure encountered in the GM-5 hole (Fig. 2-34) may be indicative of what could occur in the other holes in the vicinity, but without detailed examination of the core it is not useful to make a detailed structural and stratigraphic interpretation. The data presently available from the WR-1 and EMCO-2 holes show that a significant section of salt and red shale is apparently present at depth. The thickness and extent of a potentially large salt mass is not predictable. The stratigraphic position of the salt is also unknown, although it is probably the thick A Subzone salt.

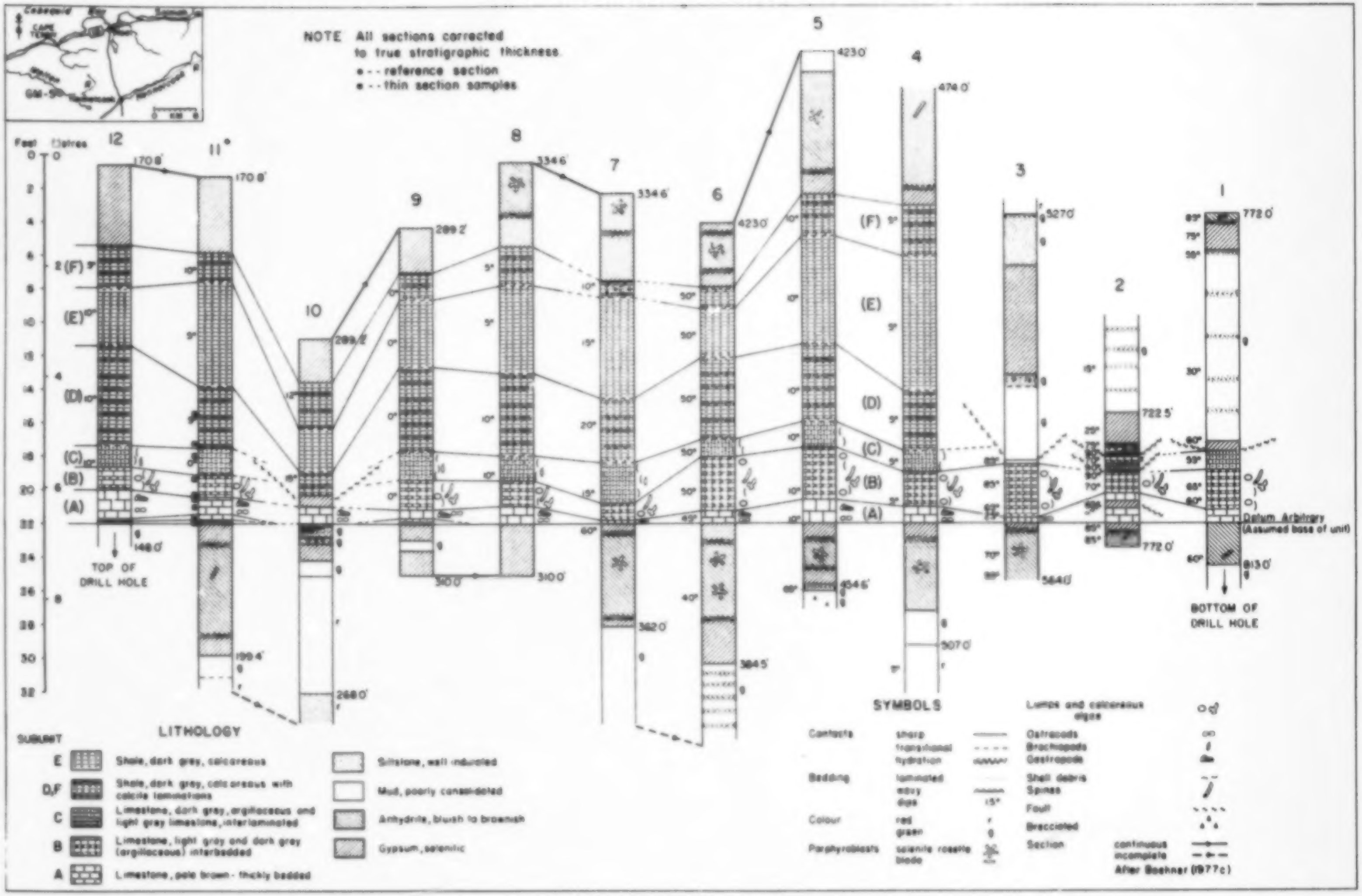

NOTE All sections corrected
to true stratigraphic thickness
• - - reference section
• - - thin section samples
GM-5
Feet
Metres
12
11°
10
9
8
7
6
5
4
3
2
1
170.8'
170.8'
289.2'
289.2'
334.6'
334.6'
423.0'
423.0'
474.0'
527.0'
722.5'
772.0'
772.0'
148.0'
199.4'
268.0'
300.0'
310.0'
362.0'
384.5'
454.6'
507.0'
564.0'
813.0'
(F)
(E)
(D)
(C)
(B)
(A)
TOP OF
DRILL HOLE
BOTTOM OF
DRILL HOLE
Datum Arbitrary
(Assumed base of unit)
LITHOLOGY
SUBUNIT
E Shale, dark grey, calcareous
D,F Shale, dark grey, calcareous with calcite laminations
C Limestone, dark grey, argillaceous and light grey limestone, interlaminated
B Limestone, light grey and dark grey (argillaceous) interbedded
A Limestone, pale brown - thickly bedded
Siltstone, well indurated
Mud, poorly consolidated
Anhydrite, bluish to brownish
Gypsum, selenitic
SYMBOLS
Contacts
sharp
transitional
hydration
Bedding
laminated
wavy
dips
15°
Colour
red
r
green
g
Porphyroblasts
selenite rosette
blade
Lumps and calcareous algae
Ostracods
Brachiopods
Gastropods
Shell debris
Spines
Fault
Brecciated
Section
continuous
incomplete
After Boehner (1977c)

Figure 2-33. Multiple structural repetition of a single carbonate unit in drillhole GM-5, Upper Walton River occurrence.

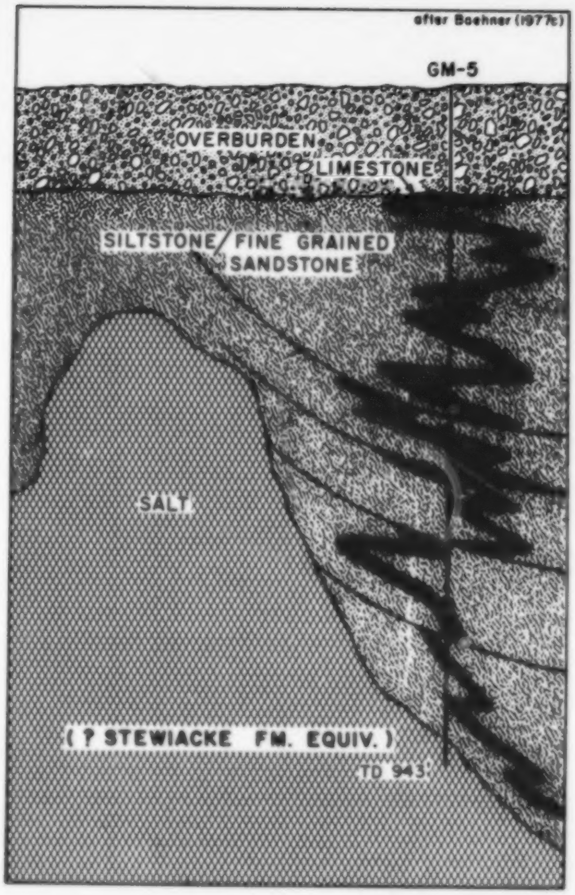


Figure 2-34. Schematic interpretation of multiple repetition in GM-5, Upper Walton River occurrence.

GEOPHYSICS

The area in the vicinity of the Upper Walton River occurrence is included on Nova Scotia Research Foundation Bouguer gravity anomaly map 11E/04 (Fig. 2-8). Unfortunately, the occurrence area has no survey stations because of the lack of road access and, therefore, contouring on the map is based upon interpolation of widely scattered data points. The presently available data indicate an ill-defined trough shaped low in the area which may be attributable to the presence of salt. A detailed survey would be required to further define the anomaly and assess the salt potential.

ECONOMIC CONSIDERATIONS

The Upper Walton River occurrence consists of halite; no potash is reported. The salt was intersected at 277 m (908 ft.) in GM-5 and first reported with red shale at 344 m (1130 ft.) in WR-1. The thickness and lateral extent of the salt is not known.

The structure in the area is extremely complex with multiple repetition of units by folding and faulting making any interpretation of stratigraphy and structure uncertain. The area is not readily accessible by road or railway although the small port at Walton is located approximately 13 km to the northwest. Based on available data this occurrence is not considered to be of economic importance.

WALTON OCCURRENCE

LOCATION

The Walton occurrence area is located near Walton (NTS 21H/01), in northern Hants County (Figs. 1-4, 1-10 and 2-35). The area is not readily accessible and can only be reached by unpaved roads and trails from Highway 15 that runs along the Minas Basin shore between Cheverie and Maitland. The terrain in the vicinity is typical of the Carboniferous Lowlands with gently undulating hills where elevations rarely exceed 75 m. Marshy areas are locally common making access difficult.

HISTORICAL BACKGROUND

The area was investigated for its potash potential as part of the Windsor Basin by Wright (1931) in a regional assessment by Hayes. Many salt springs were located indicating the leaching of salt at depth. Salt water infiltrated the underground workings of the Walton Mine. These waters are probably derived from deeply circulating groundwaters leaching salt from Windsor Group sediments to the south and east of the mine site. The general geology of the Walton area was mapped by Crosby (1962). Detailed mapping by Boyle (1963, 1972) indicated the area is structurally disturbed and extensively faulted along east-west and northwest-southeast trends.

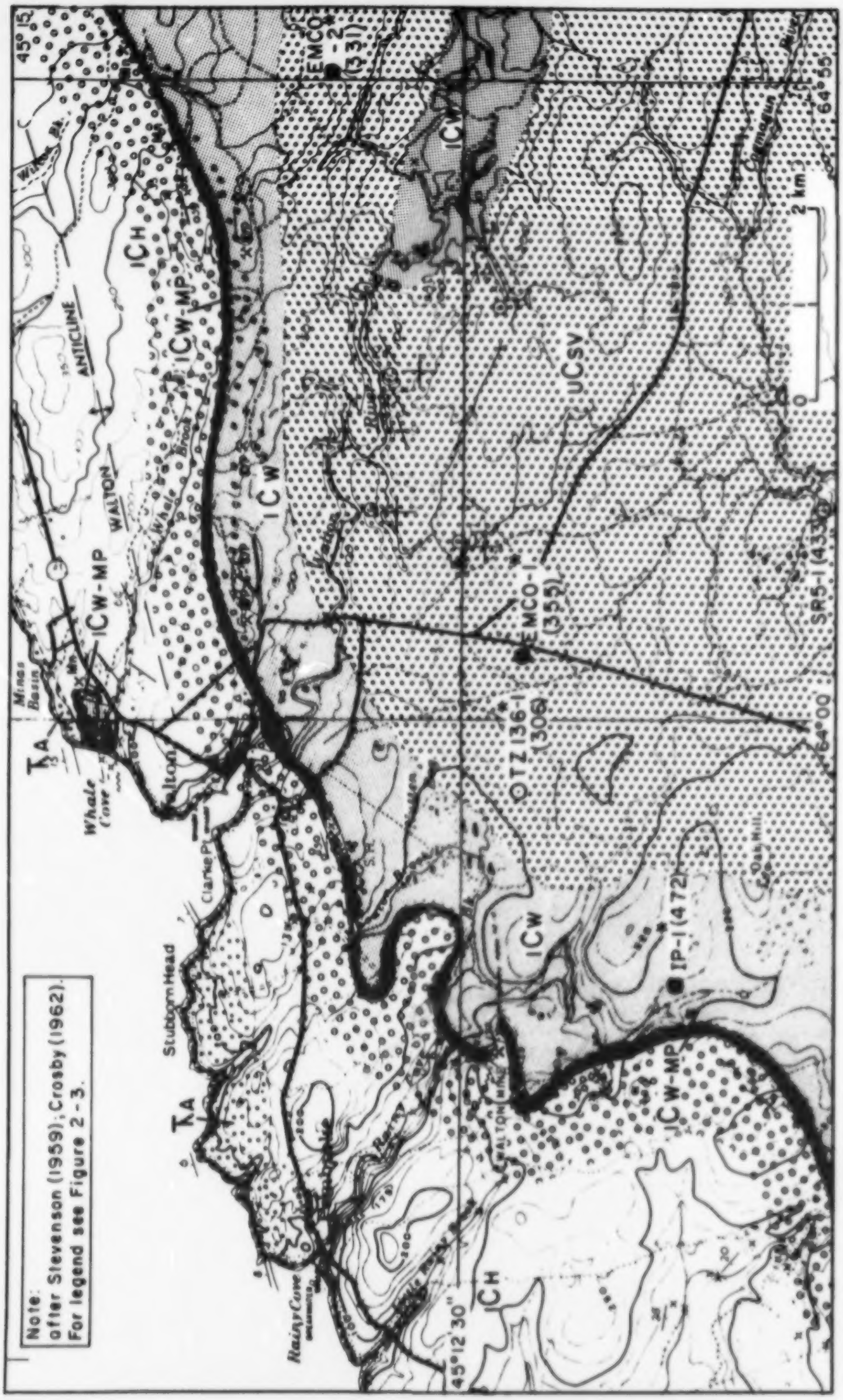
In 1967 Magnet Cove Barium Corporation drilled IP-1, 2 km south of the Walton Mine. Salt was penetrated between 472 m and 515 m and salt with anhydrite between 515 m and 520 m where the hole was stopped.

In 1969 another hole, EMCO #1, intersected salt between 355 m and 418 m where the hole was stopped. This hole was drilled 4 km east of the Walton mine and 3.7 km east-northeast of the IP-1 hole.

GEOLOGY

The geology of the Walton area (Fig. 2-35) is included on part of the Wolfville map area (21H/01) and on part of the Kennetcook map area (11E/04). Detailed mapping and extensive drilling have been concentrated along the Horton-Windsor contact although very little is known about the geology of the deeper parts of the basin away from this margin.

The stratigraphy of the Windsor Group in the area is generalized as follows: the basal


Note:
after Stevenson (1959); Crosby (1962).
For legend see Figure 2-3.

45°15'
45°12'30"
64°00'
64°55'
TrA
Minas Basin
Whale Cove
Walton
Clarke Pt.
Stubborn Head
Rainy Cove
WALTON ANTICLINE
Whale Brook
lCW-MP
lCH
lCW
uCsv
EMCO-2 (331)
EMCO-1 (355)
OTZ 136-1 (306)
IP-1 (472)
SR5-1 (433)
WALTON MINE
Oak Hill
Cogmagun River
0
2 km

Figure 2-35. Geology in the vicinity of the Walton occurrence, Hants County.

Windsor limestone is the Macumber Formation (Weeks, 1948) which overlies with apparent conformity, sandstone, shale, and conglomerate of the Horton Group. The Macumber Formation is overlain by and is equivalent in part to the Pembroke Formation which consists of limestone pebble conglomerate. This is considered by Clifton (1967) to be a post-Carboniferous solution collapse and cavity fill feature. Both are overlain by a thick basal anhydrite (gypsum), part of the Vinland Formation of Moore and Ryan (1976) or Lower Sulphate (Weeks, 1948). These units appear as relatively continuous outcrop bands along the northern outcrop limits of the Windsor, but are offset by numerous faults.

The basal anhydrite is in turn overlain by a thick sequence of red siltstone and shale (Tennycape Formation of Weeks, 1948), salt and interstratified limestone, shale, and gypsum-anhydrite beds. Due to extensive structural complexity related to faulting and folding (Boyle, 1963) the stratigraphy of this part of the section is not readily discernible from the drilling and outcrop data. The Windsor Group succession is overlain by a nearly flat lying sequence of red shales and red and grey sandstone of the Scotch Village Formation which was assigned to the Riversdale Group by Stevenson (1959); however, more recently these rocks have been dated with spores and are equivalent in age to the Pictou Group (Howie and Barss, 1975). A minimum total thickness of 200 m of Scotch Village Formation is indicated by Bell (1964) in the TZ136-1 hole drilled 2.4 km to the northeast of IP-1. This hole was stopped at 306 m without penetrating salt.

The rocks in the Walton area have been subjected to severe deformation with extensive faulting (Boyle, 1963) and complex folding. The folding is not readily seen in the Windsor Group rocks due to the scarcity of outcrop and cover of the Scotch Village Formation. Complex folding is well exposed, however, in the underlying Horton Group exposed on the Walton River north of the wharfs. This degree of deformation could be expected in the adjacent Windsor rocks, in particular, those occurring above the basal anhydrite and salt as the latter is very mobile when under stress.

The salt in the Walton occurrence probably is the thick A Subzone salt that overlies the basal anhydrite and is overlain by the Tennycape Formation (Weeks, 1948). The lateral extent and thickness variations of the salt unit are unknown and its presence is known only from very general logs of two boreholes 3.7 km apart.

GEOPHYSICS

The area in the vicinity of the Walton occurrence is included on Nova Scotia Research Foundation Bouguer gravity anomaly maps 11E/04W and 21H/01E (Figs. 2-8 and 2-13) at a scale of two inches equals one mile.

Detailed gravity surveys at a scale of 1 inch equals 200 feet by the Nova Scotia Research Foundation (1957) were directed at small mineral exploration targets along the Horton-Windsor Groups contact. In the more central parts of the Windsor outcrop area away from the contact only major roads were traversed. Because of the complex geology and widely spaced survey lines, anomalies that could be attributed to salt may not appear on Figure 2-13.

GEOCHEMISTRY

Salt springs are common in the area. The influx of salt brine into the Walton Mine indicates that salt is being actively dissolved. Cole (1930a) reported two salt springs in the vicinity. The Walton Spring (No. 13) is reported to be located on the western bank of the Walton River, approximately 450 m south of the bridge. The Rainy Cove Spring (No. 32) is reported to occur in a marshy area on the southern side of Rainy Cove Brook, 2.4 km southeast of Pembroke. Cole (1930a), reported the analyses of brine samples from these springs Table 2-7. The moderate $CaSO_4$ analysis indicates the dissolution of gypsum or anhydrite in addition to halite.

Table 2-7. Salt spring analyses, Walton area, Hants County*

Spring No.	**13**	**32**
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere , °F	76	n.d.
Temperature of brine, °F	47	n.d.
Baume degrees	n.d	n.d.
Equivalent specific gravity ..	-	-
LABORATORY NOTES		
Specific gravity at 60°F	1.0163	1.0170
Total solids at 110°C	2.14	2.41
Reaction	N	N
ANALYSES OF SOLIDS		
Na ....Per cent	31.30	30.83
K ....Per cent	0.19	0.22
Ca ....Per cent	5.13	4.89
Mg ....Per cent	0.09	0.08
SO_4 ....Per cent	11.24	11.12
Cl ....Per cent	49.28	48.34
Br ....Per cent	none	none
I ....Per cent	none	none
Total	97.23	95.48
HYPOTHETICAL COMBINATION		
$CaSO_4$ ....Per cent	15.92	15.75
$CaCl_2$ ....Per cent	1.05	0.72
$MgSO_4$ ....Per cent	-	-
$MgCl_2$ ....Per cent	0.35	0.18
K_2SO_4 ....Per cent	-	-
KCl ....Per cent	0.36	0.42
Na_2SO_4 ....Per cent	-	-
NaCl ....Per cent	79.55	78.37
Total	97.23	95.44

*Cole (1930a)

Wright (1931) reported on the salt spring occurrences in the Walton area. The Walton River Spring (Wright's Spring No. 3) occurs at the contact between Windsor "Zone A" limestone

(Macumber Formation) and the overlying gypsum. According to Wright, Spring No. 7 occurs on the southern side of the Walton-Pembroke Road where it crosses Wheaton Brook. Water is reported to be rich in hydrogen sulphide and to occur in Horton Group strata "a few hundred feet below the base of the Windsor basal sandstone". A sample was reported to show "an appreciable amount of salt but no potassium". Wright (1931) reported that the largest area of springs seen in the area are found 3 km upstream from the mouth of Rainy Cove Brook. This spring (Spring No. 9) area corresponds to the Rainy Cove Spring (No. 32) of Cole (1930a). It is reported to occur in the vicinity of the "Zone A" Windsor limestone which dips 75° south.

ECONOMIC CONSIDERATIONS

The Walton occurrence comprises halite; no potash is reported. IP-1 intersected 43 m (140 ft.) of salt at a depth of 472.4 m (1550 ft.). EMCO #1 intersected 63 m (207 ft.) of salt at a depth of 355 m (1165 ft.). The lateral extent and thickness variation of the salt is not known, nor is it possible to determine the structural configuration from the limited data available. The area is not readily accessible by road or railway. The small port at Walton is located approximately 13 km to the north. Based upon the available data, the occurrence is considered to be of little economic importance.

CHEVERIE

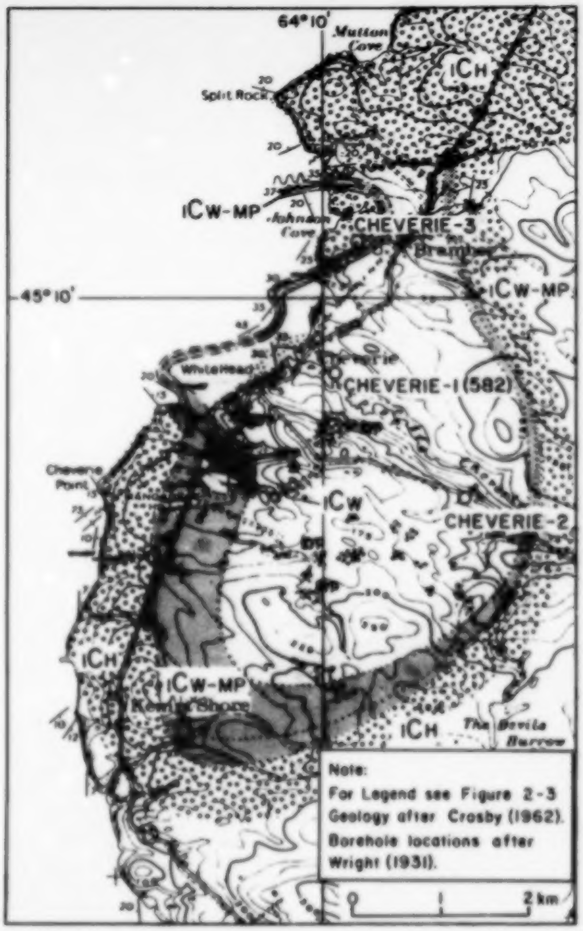
LOCATION

The Cheverie area (NTS 21H/01) is located in the northwestern part of the Hants-Colchester area and is bordered on the north by the Minas Basin and on the west by the Avon River Estuary (Figs. 1-4, 1-10 and 2-36).

HISTORICAL BACKGROUND

Geological mapping by Crosby (1962) indicated that strata of the Windsor Group underlie a large part of the area and define a small circular outlier basin. Dips around the perimeter of the basin range from 20° to 60° and the abundance of sink holes and karst topography indicate that much of the area is underlain by gypsum and anhydrite.

Salt brines were reported to have been encountered at three horizons near the bottom of Cheverie No. 1, a well drilled for petroleum in 1904 (Fig. 2-37). Two other holes are reported to have been drilled by the same company in the Cheverie area, but records of the rocks intersected could not be located according to Wright (1931). He reported that a consensus of opinion at the time was that Cheverie No. 2 intersected more than 300 m (1000 ft.) of gypsum, but Cheverie No. 3 was abandoned at relatively shallow depths. Neither was believed to have encountered salt brines.



Note:
For Legend see Figure 2-3
Geology after Crosby (1962).
Borehole locations after Wright (1931).

Figure 2-36. Geology of the Cheverie area, Hants County, Nova Scotia.

GEOLOGY

Wright (1931) reported a stratigraphic sequence (Table 2-8) for the area based upon outcrop and the borehole log (Fig. 2-37) of Cheverie No. 1. The stratigraphic sequence in Cheverie No. 1 (Fig. 2-37) agrees with that observed in outcrop with the exception of basal Windsor A Subzone limestone and sandstone. This discrepancy may be attributed to the drillers not recognizing or recording the units or to its removal by faulting. Windsor Group evaporite was encountered to a depth of 113 m (370 ft.) where the Horton shale and sandstone sequence was intersected to the total depth of 582 m (1910 ft.).

A salt water flow in the Horton Group was encountered in the Cheverie No. 1 borehole in a 6 m (20 ft.) bed of grey sandstone at 305 m (1000 ft.), in an 8 m (30 ft.) bed of dark grey sandstone at 552 m (1810 ft.) and in a 6 m (20 ft.) bed of whitish grey sandstone at 576 m (1890 ft.) (Table 2-9). In all instances the brines

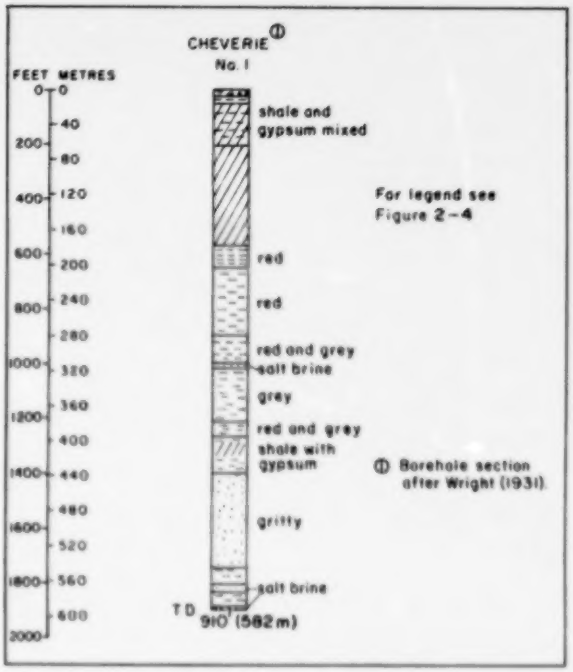


Figure 2-37. Drillhole profile, Cheverie No. 1, near Cheverie.

Table 2-8. Stratigraphic section, Cheverie area*

WINDSOR GROUP
Subzone B Grey fossiliferous limestone 3 m (10 ft.).

Subzone A Gypsum and anhydrite 113 m (370 ft.)
Laminated limestone 15 m (50 ft.)
Red shale 15 m (50 ft.).
Laminated limestone 15 m (50 ft.)
Grey massive sandstone 18.3 m (60 ft.) with Schizodus.

Local Unconformity

HORTON GROUP
Cheverie Formation
Shale and sandstone 396 m (1300 ft.).

Lower Horton
Black shales.

*Wright (1931)

were found in sandstones capped by shales. Slightly saline springs were reported near Wheaton Brook and East Noel by Wright (1931), which is a further indication of a possible salt occurrence in the area.

Wright (1931) reported analyses of Cheverie brine (Table 2-9) that were obtained from L. H. Cole (the analyst of the brine was unknown). The brine is far more concentrated than most natural salt springs and consists mainly of dissolved salt with $CaCl_2$ and $CaSO_4$.

Table 2-9. Chemical analyses of Cheverie brine* (Wright, 1931).

Specific Gravity at 15° C...1.1387

Calcium sulphate	0.3957550
Calcium chloride	0.5152726
Magnesium chloride	0.3261256
Ferrous carbonate	0.0027988
Sodium chloride	16.8279620
Total mineral matter ...	18.0679140
Water	81.9320860
Total	100.0000000

An Imperial Gallon of Cheverie brine contains:

	Grains**
Calcium sulphate	315.46433
Calcium chloride	410.74208
Magnesium chloride	259.96628
Ferrous carbonate	2.23704
Sodium chloride	13414.16587
Total mineral matter ...	14402.57560
Water	65310.97440
Total	79713.55

* Analyst Unknown
** 1 grain = 0.0648 gm

GEOPHYSICS

The Cheverie area is included on Nova Scotia Research Foundation Bouguer gravity anomaly map 21H/01E at a scale of two inches equals one mile (Fig. 2-13). The anomalies do not suggest any significant concentration of salt in the area.

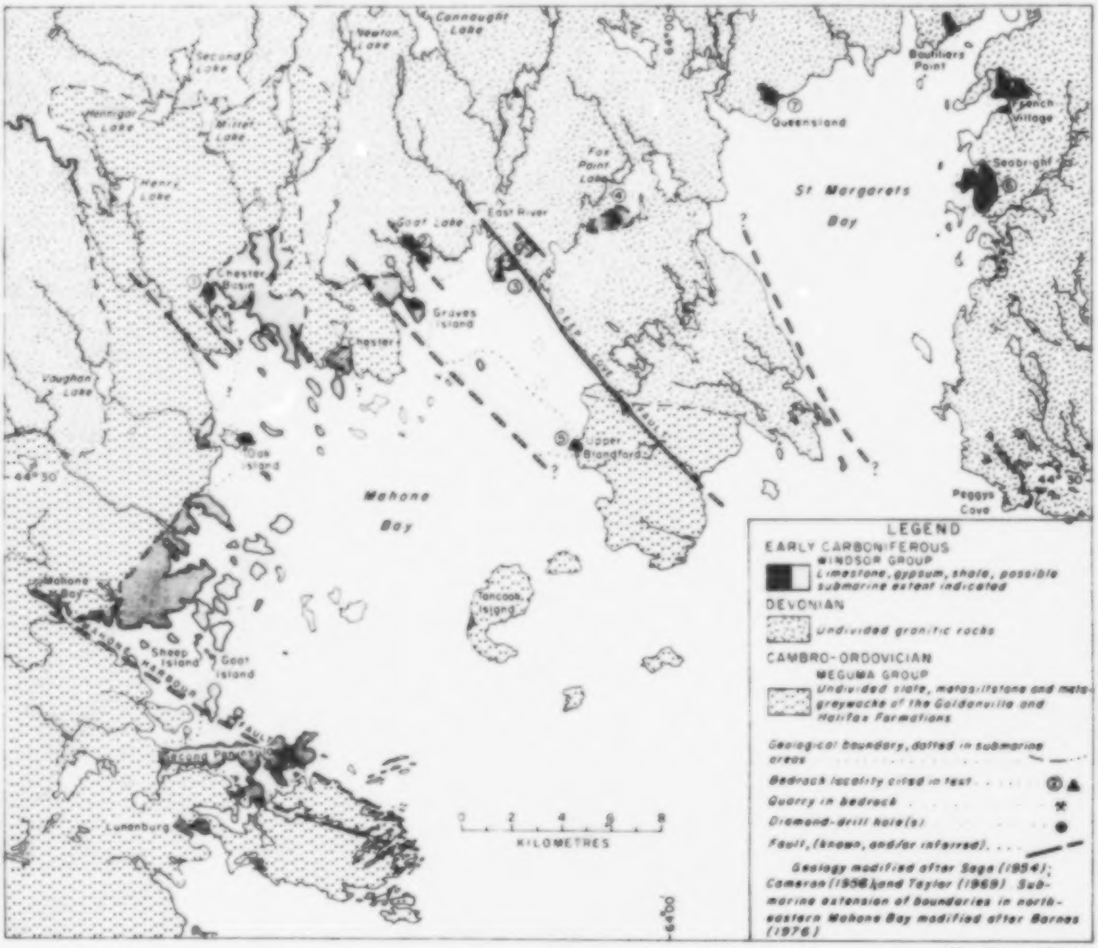
Rock salt has not been encountered in the Cheverie area although concentrated salt brines are known to be present in Horton Group sandstone units capped by shale. The source of these salt brines is not certain. The Horton Group sediments in the area are not known to have salt beds, however equivalent age rocks in New Brunswick and Cumberland Sub-basin do have rock salt. The high salinity and composition of the brine makes the possibility of normal seawater infiltration remote and favours a rock salt or connate brine source. Faulting of the Horton Group and the salt bearing Windsor Group with accompanying brine migration into the aquifers of the Horton Group is a plausible explanation.

ECONOMIC CONSIDERATIONS

The Windsor Group strata occur in a small basin consisting principally of the A Subzone basal limestone-sandstone and basal anhydrite section, but some B Subzone limestone is reported in the central area. In an undisturbed section, the main salt of the Windsor Group should lie between the thick A Subzone anhydrite and the cyclic B Subzone, but has not been encountered in the drilling. The high degree of deformation indicated in the area by Boyle (1963, 1972) together with the thin cover strata of the B Subzone and the absence of salt springs indicate the area is unfavourable for the occurrence and preservation of significant rock salt deposits.

CHAPTER 3
MAHONE BAY AREA

Windsor Group rocks in the vicinity of Mahone Bay and St. Margarets Bay (Figs. 1-4, 1-10 and 3-1) were mapped by Sage (1954) and Giles (1982). In this area the Windsor Group was described as directly overlying pre-Carboniferous basement (granite). Evaporite rocks including gypsum and anhydrite were not reported in outcrop although possible indications of their presence was locally indicated by sinkholes. Boulders of limestone bearing Gigantoproductus and a variety of colonial rugose corals were reported from several localities and were considered to be part of the E Subzone. Moore and Austin (1979) and Boehner (1977b) considered these to be correlative with the C Subzone, Herbert River Limestone Member. Giles (1982) studied the Windsor Group rocks in the area and reassigned and correlated with parts of the Shubenacadie-Musquodoboit Basin stratigraphy. Units correlative with the Gays River, Carrolls Corner and Meaghers Grant Formations were recognized; however, the presence of salt was considered to be improbable. Based upon this work and the absence of Bouguer gravity lows, the Mahone Bay area is believed to have little potential for salt exploration.


Connaught Lake
Newton Lake
Second Lake
Hennigar Lake
Miller Lake
Henry Lake
Vaughan Lake
Goat Lake
East River
Fox Point Lake
Chester Basin
Chester
Graves Island
Oak Island
Upper Blandford
Queensland
Boutiliers Point
French Village
Seabright
St Margarets Bay
Mahone Bay
Mahone Bay
Tancook Island
Sheep Island
Goat Island
Second Peninsula
Lunenburg
Peggys Cove
44°30'
64°00'
0 2 4 6 8
KILOMETRES
LEGEND
EARLY CARBONIFEROUS
WINDSOR GROUP
Limestone, gypsum, shale, possible submarine extent indicated
DEVONIAN
Undivided granitic rocks
CAMBRO-ORDOVICIAN
MEGUMA GROUP
Undivided slate, metasiltstone and metagreywacke of the Goldenville and Halifax Formations
Geological boundary, dotted in submarine areas
Bedrock locality cited in text
Quarry in bedrock
Diamond-drill hole(s)
Fault, (known, and/or inferred)
Geology modified after Sage (1954); Cameron (1956) and Taylor (1969). Submarine extension of boundaries in northeastern Mahone Bay modified after Barnes (1976)

after Giles (1982)

Figure 3-1. Geology of the Mahone Bay area.

CHAPTER 4 CUMBERLAND AREA

INTRODUCTION

The Cumberland area in northern Nova Scotia (Fig. 1-10) is the major salt producing area in Atlantic Canada. Canada's first underground salt mine was established here by the Malagash Salt Company in 1919 and operated until 1959. Presently, two salt deposits are being exploited. The Nappan vacuum-evaporating brining operation of Domtar Chemicals Ltd., which opened in 1947, has a present annual production of approximately 100 000 short tons. The Pugwash underground mine, operated by Canadian Salt Company, opened in 1959, has a present annual production of approximately 1 000 000 short tons.

Four salt deposits and two salt occurrences are recognized in the Cumberland area (Fig. 1-4). In each case they are related to large diapiric intrusions of Windsor Group rocks in the axial areas of faulted anticlines. Bouguer gravity anomalies coincident with the anticlines indicate that salt is probably present throughout their length although only the salt relatively close to the surface has been explored. Deep drilling by petroleum exploration companies indicates that salt occurs in great thicknesses in the structures. Potash mineralized intervals have been reported from the salt at Nappan, Oxford, Pugwash, and Malagash, although from present data it appears to occur in relatively small discontinuous masses of low grade (less than 5% K_2O). Two salt occurrences recognized in the area are at Beckwith and Roslin. In addition, there are several areas where salt is strongly suggested, but has not been established by drilling.

The Cumberland area is considered to be one of the better areas for commercial deposits of potash based on its stratigraphic and structural similarities and proximity to the recently discovered New Brunswick potash deposits at Sussex and Salt Springs (Worth, 1972; Anderle et al. 1979; Kingston and Dickie, 1979; and McCutcheon, 1981). An additional favourable factor is that the presence of potash salts has already been established in the area.

In addition to their historical importance in salt mining, the salt deposits in the Cumberland area have potential for underground storage. Relatively new and continually advancing geostorage technology has been directed at the use of salt structures for the development of underground caverns through solution mining. These caverns can be used for a variety of purposes including petroleum storage and, with newly developed technology, for the possible storage of compressed air for peaking power when Fundy Tidal Power is developed. The salt deposits and occurrences in the Cumberland area are described in alphabetical order and include: Beckwith, Malagash, Nappan, Oxford, Pugwash, and Roslin.

GENERAL GEOLOGY OF THE CUMBERLAND AREA

The Cumberland area (Fig. 1-10) is located in parts of Cumberland, Pictou and Colchester Counties in northern Nova Scotia. The area is underlain by a very thick sequence of Carboniferous rocks which occurs in part of the Cumberland Sub-basin defined by Bell (1944, 1958) as that area to the north of the present day Cobequid Uplands. Although Carboniferous sediments comprise the major portion of the post-Acadian rocks in the Cumberland area, biostratigraphic data (Howie and Barss, 1975) indicate the presence of rocks as old as Middle Devonian and possibly as young as Early Permian (Pictou Group). The Carboniferous and Middle to Late Devonian rocks are confined to a deep, block faulted trough. They are bordered on the south by Early Proterozic to Middle Carboniferous aged rocks of the Cobequid Highlands and to the north, in part, by the crystalline basement of the Westmorland Upland. A smaller intrabasinal basement high occurs in the vicinity of Hastings on the northern side of the Minudie Anticline.

This summary is not intended to critically assess the validity of depositional models, stratigraphy or tectonics in the area. In the absence of more detailed and direct examination of these aspects it is only possible to restate what has already been discussed by previous workers. More detailed assessments may be found in published work by Bell (1926, 1944, 1958), Shaw (1951), Copeland (1959), Howie and Barss (1975), Poole et al. (1970), Poole (1976), Kelley (1967a), Belt (1968), van de Poll (1972), White (1972), Donohoe (1976), Wallace and Donohoe (1977), Donohoe and Wallace (1978), and in the unpublished work of petroleum exploration interests and others.

The Cumberland Sub-basin is an east-west trending sedimentary basin containing up to 8000 m of terrigenous clastic and marine evaporite sediments deposited in the waning stages of and after the Acadian (Devonian) Orogeny (Howie and Barss, 1975). It is part of a larger depositional area variously named the Fundy Basin, Fundy Epieugeosyncline, or Fundy Aulacogene that developed upon the broken Acadian Orogen in Atlantic Canada during a series of tectonic episodes collectively termed the Maritime Disturbance (Poole et al., 1970). Sedimentation in the Sub-basin was, for the most part, dominated by post-Devonian (post-Acadian) nonmarine clastic shedding from highlands (inter- and intra-basinal) although the Middle to Late Devonian terrigenous derived clastic rocks with volcanic rocks are possibly syntectonic (van de Poll, 1972). The only major marine sedimentation occurred during the deposition of the Windsor Group when basin restriction and extensive evaporite sedimentation ($CaSO_4$ and NaCl) prevailed. These thick evaporite deposits occur in the present configuration as thickened walls, ridges and domes in halotectonic (Halbouty, 1967) diapiric anticlinal structures that extend to depths of 5000 m and locally up to 6100 m according to Howie and Barss (1975). The structures appear to have the configuration of tight en echelon anticlines with longitudinal bounding faults that are locally offset by transverse faults. White (1972) concluded that the evaporites separated the basement block faulted tectonic regime from the overlying salt tectonic regime both of which occur in a rift basin setting. This assessment is an extension of the rift basin model outlined by Belt (1968).

Due to the severely deformed nature of the Windsor Group strata forming the diapiric intrusions, the stratigraphy of the Windsor Group is generally very difficult to assess and where possible, only within restricted limits. The total original thickness of the Windsor Group prior to deformation is not directly ascertainable although Bell (1958) indicated 180 m as a minimum. According to Howie and Barss (1975) the great variation in thickness of the Windsor Group is probably the result of evaporite flowage into the deeper parts of the basin due to gentle tilting, uplift and faulting shortly after deposition and/or during later tectonic or sedimentary events.

The original lateral extent of the Windsor Group deposition is not readily determinable in the Cumberland Sub-basin due to burial by the very thick, overlapping sequences of the younger nonmarine Late Carboniferous strata. The distribution of Windsor Group strata may have been strongly influenced by intrabasinal uplifts, ie. the Hastings uplift with nondeposition or subsequent erosion. Deposition of marine carbonates may not have continued beyond the C Subzone with the younger strata apparently represented entirely by terrigenous clastic rocks assigned in part to the Middleborough Formation. A similar situation has been described above the major basal evaporite cycle of the Windsor Group in New Brunswick by McCutcheon (1981). The apparent lack of younger carbonate strata may be in part a function of exposure and faulting.

Bell (1944), determined three categories for the Cumberland area Windsor Group outcrop areas:

> ... (1) elongate areas containing the loci of the main anticlinal axes of post-Pictou folds; (2) elliptical or polygonal areas, representing upfaulted blocks located upon anticlinal, post-Pictou folds; and (3) roughly elliptical areas representing subordinate dome-like folds on major post-Pictou anticlines, or similar domes partly upraised by a fault or faults.

Bell (1958) suggested that the major "salt anticlines" in the Cumberland Sub-basin probably originated as a result of post-Canso and/or post-Riversdale tectonism. He further suggested that the movement of the easily mobilized evaporite rocks was furthered by the weight of the continued accumulation of Riversdale Group and Cumberland Group rocks. The presence of angular unconformities adjacent to the Windsor Group outcrop areas is important in dating the movement history of the structures. Pictou Group rocks lie with angular unconformity on the Riversdale Group and locally, on the Windsor Group.

The stratigraphic and structural relationships outlined above together with their association with large salt structures indicate that the present outcrop distribution patterns are partly due to Pictou Group onlap onto progressively older units towards the axes of the anticlines. These anticlines were apparently faulted and diapiric in the later part of their development history. They have probably controlled, and were controlled to some extent, by sedimentation. The development sequence for each major structure may not necessarily be isochronous although major tectonic events would obviously have some control.

The hypothesis that the salt structures have developed over a period of time in response to tectonic (faulting) and sedimentary events is not new. Bell (1944) postulated that the progressive rise of Windsor Group evaporites adjacent to the Springhill coalfield (Cumberland Group) may have been controlled by increases in the sedimentary load and may have promoted the depositional conditions for coal and the local deposition of the Cumberland Group. The anticlinal salt structures themselves may have influenced, to varying degrees, local sedimentation. They appear in some instances to have pierced overlying strata and with renewed sedimentation were subsequently overlain (with angular unconformity) by still younger strata. Other structures may be related to post-Carboniferous (Late Carboniferous-Triassic?, van de Poll, 1972) faulting and subsequent evaporite intrusion. Howie and Cumming (1963) suggested that the salt-cored structures in the Cumberland area were the result of slide faulting associated with Cobequid Mountain uplift or of a combination of salt tectonics and northwestward thrusting.

Evans (1967, 1972) described the structure and stratigraphy of the Windsor Group strata exposed in the Pugwash Mine. This work revealed the highly complex and severely deformed nature of the evaporite rocks. When comparisons were made to Gulf Coast domes, the folding and orientation of the structural elements were markedly different. Evans (1967, 1972) concluded that the internal fold structures within the salt mass were modified by the folding of the Pictou Group whose major anticlinal axial plane corresponded closely with axial plane traces within the Windsor Group. Some of the structural attributes of the Pugwash structure are influenced by the lithologic inhomogeneity of the evaporite mass. The proportion of relatively competent thick anhydrite beds has no comparison in the Gulf Coast domes which are typically high purity salt. It is therefore apparent that direct comparisons regarding sedimentation and tectonics are not possible. Zechstein diapirs in northwestern Germany described by Richter-Bernburg (1972) appear to be similar in lithology (heterogeneous) and gross structural configuration to the Windsor Group diapirs in the Cumberland area.

Bidgood (1970) described the general geophysical (gravity, magnetic) aspects of the salt structures in the Cumberland area. The Bouguer gravity anomaly map (Fig. 4-1) for the area shows a number of negative anomalies coinciding with known Windsor Group outcrop areas including Malagash-Wallace, Simpson Lake (Head of Wallace Bay), Pugwash, Canfield Creek, Beckwith, Oxford, Roslin, Springhill (Black River) and Nappan areas (Fig. 1-10). Bidgood (1970) attributed these anomalies to diapiric low density salt masses that penetrated upwards along faults and into fold axes (mainly cores of anticlines), with vertical dimensions up to 3 km and widths ranging between 1.2 and 12 km. Seismic work in the Pugwash and Wallace areas yielded data on the

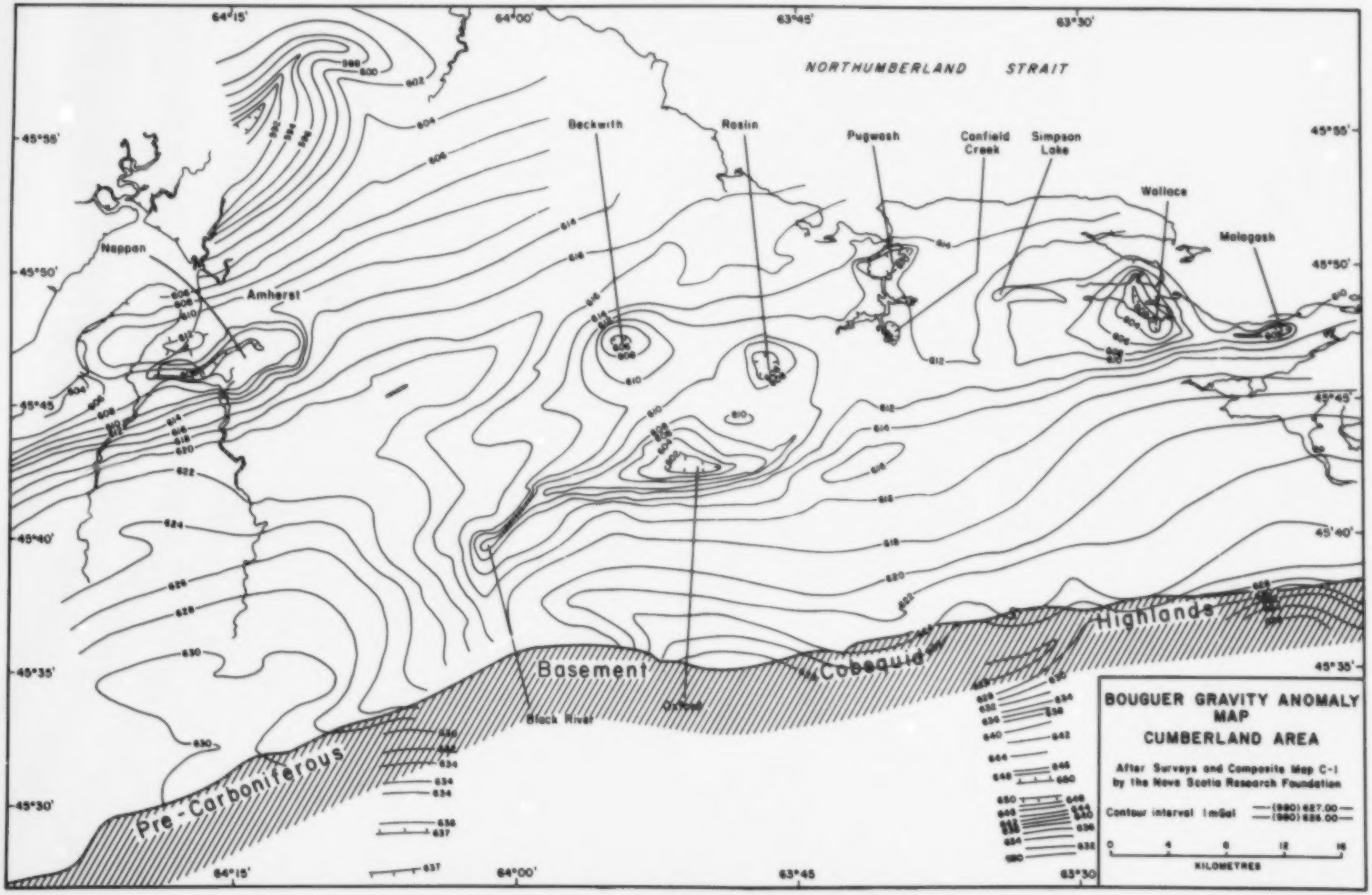

NORTHUMBERLAND STRAIT
64°15'
64°00'
63°45'
63°30'
45°55'
45°50'
45°45'
45°40'
45°35'
45°30'
Nappan
Amherst
Beckwith
Roslin
Pugwash
Canfield Creek
Simpson Lake
Wallace
Malagash
Black River
Oxford
Basement
Cobequid
Highlands
Pre-Carboniferous
598
600
602
604
606
608
610
612
614
616
618
620
622
624
626
628
630
634
636
637
640
642
644
646
648
650
BOUGUER GRAVITY ANOMALY MAP
CUMBERLAND AREA
After Surveys and Composite Map C-1 by the Nova Scotia Research Foundation
Contour interval 1mGal
(980) 627.00
(980) 626.00
0
4
8
12
16
KILOMETRES

Figure 4-1. Bouguer gravity anomaly map and salt diapirs, Cumberland area.

subsurface nature and extent of the intrusions. A north-south seismic profile across the Wallace structure was interpreted by Bidgood (1970) to indicate shallow southward dips in the Windsor Group except in the immediate vicinity of the salt intrusion. He indicated a depth to the major salt of 2100 m in the south and 1800 m in the north. The intrusion is associated with a fault. A north-south seismic profile near Canfield Creek south of Pugwash showed a similar configuration, according to Bidgood (1970), with dips to the south and a depth to salt of 2400 m in the south and 2100 m in the northern end of the profile. Steep dips are indicated on the flanks of the intrusion and Bidgood (1970) suggested that the Malagash Anticline between Oxford and Malagash is salt cored and may be fault controlled. These seismic sections support the interpretation of major diapiric evaporite movement in the Cumberland area.

BECKWITH OCCURRENCE

LOCATION

The Beckwith occurrence is located in the Little River Beckwith area (Figs. 1-4, 1-10 and 4-2) approximately 6.5 km north of Oxford, Cumberland County, northern Nova Scotia (NTS 11E/13W). The area lies between the Shinimicas River and River Philip which empty into the Northumberland Strait 13 km to the northeast.

The area is readily accessible by paved Highway 204 and gravel roads connected with the Trans-Canada Highway 104 between Truro and Amherst. The main line of the Canadian National Railway between Truro and Moncton passes south of Oxford.

The terrain in the vicinity is typical of the Carboniferous Lowlands with gently rolling hills rarely exceeding 75 m in elevation.

HISTORICAL BACKGROUND

Cumberland County was investigated for its potash potential by Hayes (1931). At that time the Beckwith-Little River area was not examined due to the absence of such indicators as salt springs or seeps.

In 1966 Scurry-Rainbow Oil Ltd. undertook a sulphur exploration program in the Province with Windsor Group salt structures as the major objective. The Beckwith area was selected for drill exploration after a gravity survey by the Nova Scotia Research Foundation outlined a significant negative Bouguer gravity anomaly in the vicinity (Fig. 4-1). Although a total of five holes were drilled, only the SR27-3 hole was reported to have intersected salt, with halite veins from 313 m (1028 ft.) to total depth at 315 m (1035 ft.). This drillhole consisted of steeply dipping red shale and minor grey shale. Typical Windsor Group siltstone, gypsum and limestone were intersected in two other holes, but they were abandoned before reaching salt. Sulphur or potash was not reported in any of the drilling.

GEOLOGY

The Beckwith area was mapped by Bell (1945) as part of the Shinimicas sheet (Fig. 4-2). Strata mapped in the area belong to Windsor, Canso-Riversdale and Cumberland-Pictou Groups. The major structure present is a Windsor Group cored faulted anticline along the trend of the Minudie Anticline.

The Beckwith structure has a triangular outline with a concentric unit succession from core to margin comprising Windsor Group evaporite, limestone and shale; Middleborough Formation (Canso Group?), red sandstone, shale and minor conglomerate; Boss Point Formation (Riversdale Group), grey and red sandstone and shale, limestone-conglomerate; Cumberland Group, grey and red sandstone, grit and conglomerate, and red shale; and Pictou Group, red sandstone, shale, grit and conglomerate. The Pictou Group succession is faulted against the structure's northern border which has an east-northeast strike.

In 1966 Scurry-Rainbow Oil Ltd. drilled five sulphur exploration holes (Fig. 4-3) in the central part of the Beckwith dome (Fig. 4-2). The salt intrusion believed to be responsible for the Bouguer gravity negative anomaly outlined in a gravity survey by the Nova Scotia Research Foundation was not penetrated. A major salt mass is probably present at depth, but would require deeper drilling to establish. SR27-1, drilled near the Windsor-Middleborough contact on Purdy Brook, penetrated only steeply dipping red shales and was abandoned at 136 m. Nearby SR27-2 penetrated only gypsum (bedding dips unknown) and was stopped at 70 m in a sandstone-gypsum breccia. SR27-3, drilled approximately 1 km southeast of SR27-1, penetrated only red shales with minor salt veins at the bottom and was abandoned at 315 m. SR27-4, drilled approximately 0.6 km north-northwest of SR27-1, intersected a thick section of red shale to 173 m and then a section of interstratified limestone, green-red shale, and gypsum when the hole was abandoned at 246 m. SR27-5, drilled approximately 1.8 km north of SR27-1, penetrated a thick section of interbedded red-grey sandstone, and shale with some thin calcareous conglomerate and was abandoned at 276 m. This sequence, although in an area mapped as Windsor, is probably part of the overlying Upper Carboniferous succession. It may be assigned to the Claremont Formation and/or Boss Point Formation but possibly may be as young as Pictou Group. The presence of this sequence indicates that younger rocks occur on the southern side of the fault, but due to the scarcity of outcrop in the area the map unit boundaries and overall configuration are subject to revision (Figs. 4-2 and 4-4). The outcrop area of the Windsor Group is probably smaller and the geology more complex than that mapped by Bell (1945).

GEOPHYSICS

The Beckwith area is included on Nova Scotia Research Foundation Bouguer anomaly map 11E/13 at a scale of 1:31 680 and on a Scurry Rainbow Oil Ltd. map (Fig. 4-4). The Nova Scotia Research

Foundation (1966a) interpreted the anomaly using a spherical model with a density contrast of 0.25 g/cc, and a radius of 2073 m (6800 ft.) centred at a depth of 2316 m (7600 ft.). A good fit of computed gravity and observed gravity was indicated. In the fitting of gravity data the selection of the density contrast is based upon assumed mean density values of 2.20-2.25 g/cc for Windsor Group evaporites and 2.40-2.50 g/cc for younger clastic rocks. The density contrast value is critical and any variations from its true value will affect both the depth and size of the interpreted body.

ECONOMIC CONSIDERATIONS

The occurrence, as is presently known, comprises halite veins only and the parent salt mass has not been intersected. The presence of potash minerals is possible, but may only be tested by further deeper drilling. The depth to the main salt mass is in excess of 300 m, probably in the order of 450 to 600 m. Salt springs have not been reported in the area. The area is located within 6.5 km of the Canadian National Railway mainline between Truro and Moncton. The occurrence as presently known is not considered to be of economic importance.

MALAGASH DEPOSIT

LOCATION

The Malagash deposit is located in the Malagash-Wallace area (Figs. 1-4, 1-10 and 4-5) Cumberland County, northern Nova Scotia (NTS 11E/14). Malagash is located on the Malagash Penninsula which forms a ridge into the Northumberland Strait between Tatamagouche Bay on the south and Wallace Harbour on the north. The Malagash deposit in this report includes not only the Malagash Mine structure, but also includes the broader western extension of this structure in the Wallace area.

The area is readily accessible by paved highways (including Routes 6, 368 and 246) from Pictou, Oxford and Pugwash, and a series of unpaved roads. The Canadian National Railway line is located in Wallace Station 2.5 km south of the town of Wallace which is located on the southern shore of Wallace Harbour.

The terrane in the Malagash area is typical of the Carboniferous Lowlands in northern Nova Scotia with gently rolling hills where elevations rarely exceed 75 m. A distinct ridge coincides with the Malagash Anticline. The Northumberland Strait shoreline is characterized by broad shallow river estuaries and bays.

HISTORICAL BACKGROUND

The Malagash Salt Mine was the first underground salt mining operation in Canada. Interest in the area was sparked in the later part of the nineteenth century by discoveries of salt springs and seeps. In 1912, salt water was encountered at a depth of 25 m in a water well bored approximately 11 km northeast of Malagash Station (near the future site of the Malagash Mine). A detailed historical summary of the pre-1912 references to salt was described by Hayes (1920) and Cole (1930a,b). In 1917 Chambers and McKay were sufficiently encouraged by analyses of the well water brine to begin a churn drill exploration program for salt in the vicinity. Twelve holes were sunk with salt brine encountered in six, at depths varying from 26 to 34.4 m (85 to 113 ft.) below the surface. Based on the success of the initial drilling a diamond-drill hole was then drilled on the site to test for the presence of rock salt. Salt was intersected from 28.7 to 52.7 m (94 to 173 ft.) below the surface and a shaft was sunk 137 m east of the diamond-drill hole to further assess the salt deposit. The shaft penetrated salt at a depth of 26 m (85 ft.). Further diamond-drilling both underground and from the surface confirmed the existence of an exploitable salt deposit and commercial production of salt from the Malagash salt mine operated by the Malagash Salt Company began in 1919. Hayes (1920) described the early history of mine development and its basic geological situation.

Potash minerals in small quantities were encountered in 1919. The potash occurred in variably thick discontinuous lenses and pods of crystalline, pink and green sylvite in a halite matrix. Ellsworth (1926) analyzed samples taken over the potash mineralized intervals.

Mining, engineering and ore grade problems culminated in the closure of the operation in early 1959. By this time the operators had successfully explored and developed the Pugwash mine at Pugwash, 26 km to the west. A history of the Malagash Mine from its discovery to abandonment has been compiled by MacQuerrie (1975).

In 1965-1966 geophysical and geological programs by the Nova Scotia Research Foundation and Nova Scotia Department of Mines, funded by the Atlantic Development Board resulted in a deep diamond-drill exploration program for potash in the Malagash-Wallace area. Four holes were drilled to the west of the Malagash Mine to assess the geology and potential extension of the potash mineralized zones known to occur in the Malagash Mine. Two holes were successful in intersecting significant potash mineralized zones.

No further potash exploration drilling has been undertaken in the area since the 1966 Potash Program. Exploration has apparently been discouraged by the great depth and low grade of the mineralized interval as it is presently known. Recent discoveries of potash deposits in similar circumstances in New Brunswick may encourage a reassessment of the potash potential.

In 1973, Anschutz Corporation drilled Wallace Station No. 1 near Wallace Station, 5 km west of Wallace No. 1, in exploration for petroleum. The Windsor Group salt zone was intersected between 2506 and 3980.7 m (8222 and 13 060 ft.).

GEOLOGY

The Malagash area has been investigated by many workers since early (pre-1900) geological exploration began in Nova Scotia. The geology of

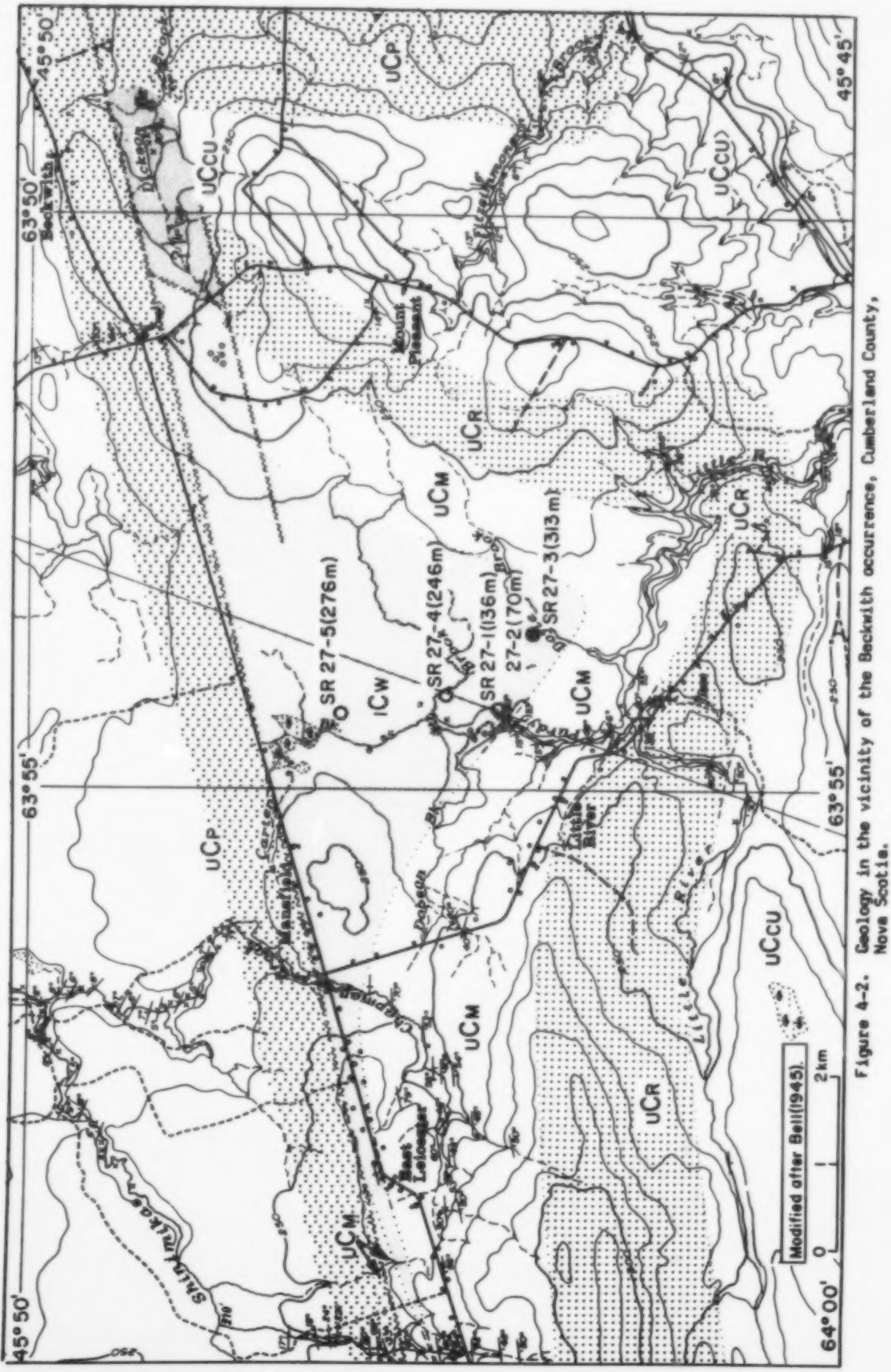

45°50'
63°50'
Beckwith
Dickson
Brook
uCp
uCcu
Mount Pleasant
uCR
uCM
SR 27-5(276m)
lCw
SR 27-4(246m)
SR 27-1(136m)
27-2(70m)
SR 27-3(313m)
63°55'
Little River
Little River
East Leicester
Shinimikas
uCcu
uCR
uCM
Modified after Bell(1945)
0
2km
45°45'
64°00'

Figure 4-2. Geology in the vicinity of the Beckwith occurrence, Cumberland County, Nova Scotia.

LEGEND

UPPER CARBONIFEROUS

UCP PICTOU GROUP
Undivided sandstone, shale and congolmerate

UCCU CUMBERLAND GROUP
Undivided sandstone, conglomerate and shale

UCCU-U Upper Division: sandstone, shale and coal

UCCU-L Lower Division: conglomerate, sandstone and shale

UCR RIVERSDALE GROUP
Undivided sandstone, conglomerate and shale

UCR-BP *BOSS POINT FORMATION:* sandstone and shale

UCR-C *CLAREMONT FORMATION:* conglomerate

UCCa CANSO GROUP
Undivided sandstone and shale

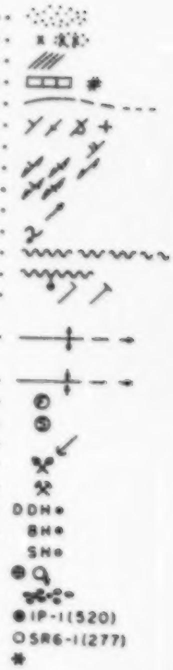
UCM *MIDDLEBOROUGH FORMATION:* (may include Windsor Group or Canso Group) shale and sandstone

LOWER CARBONIFEROUS

ICW WINDSOR GROUP
Undivided shale, gypsum, anhydrite, halite and limestone

SYMBOLS

Heavily drift-covered area ....
Rock outcrop, area of outcrop ....
Limestone or dolomite outcrop (Faribault-Fletcher maps) ....
Gypsum outcrop ....
Geological boundary (defined, approximate, assumed) ....
Bedding, tops known (inclined, vertical, overturned, horizontal) ....
Bedding, tops unknown (inclined) ....
Schistosity (inclined, vertical, dip unknown) ....
Gneissosity (inclined, vertical) ....
Plunge of minor fold ....
Drag fold (arrow indicates plunge) ....
Fault (defined, approximate, assumed) ....
Fault (solid circle indicates downthrow side) ....
Joint (inclined, vertical) ....
Anticline (defined, approximate, arrow indicates direction of plunge) ....
Syncline (defined, approximate, arrow indicates direction of plunge) ....
Fossil locality ....
Spore sample ....
Glacial striae (ice flow direction known) ....
Gravel deposit ....
Quarry ....
Diamond-drill hole ....
Borehole ....
Sinkhole ....
Salt spring ....
Observed karst topography ....
Drillhole intersecting salt; number (depth to salt, metres) ....
Drillhole without salt; number (Total depth, metres) ....
Drillhole location precise to 150 m ....



MINERALS

Anhydrite	ah	Limestone	lst
Gypsum	gyp	Pyrite	py
Lead	Pb	Zinc	Zn
Celestite	Sr		

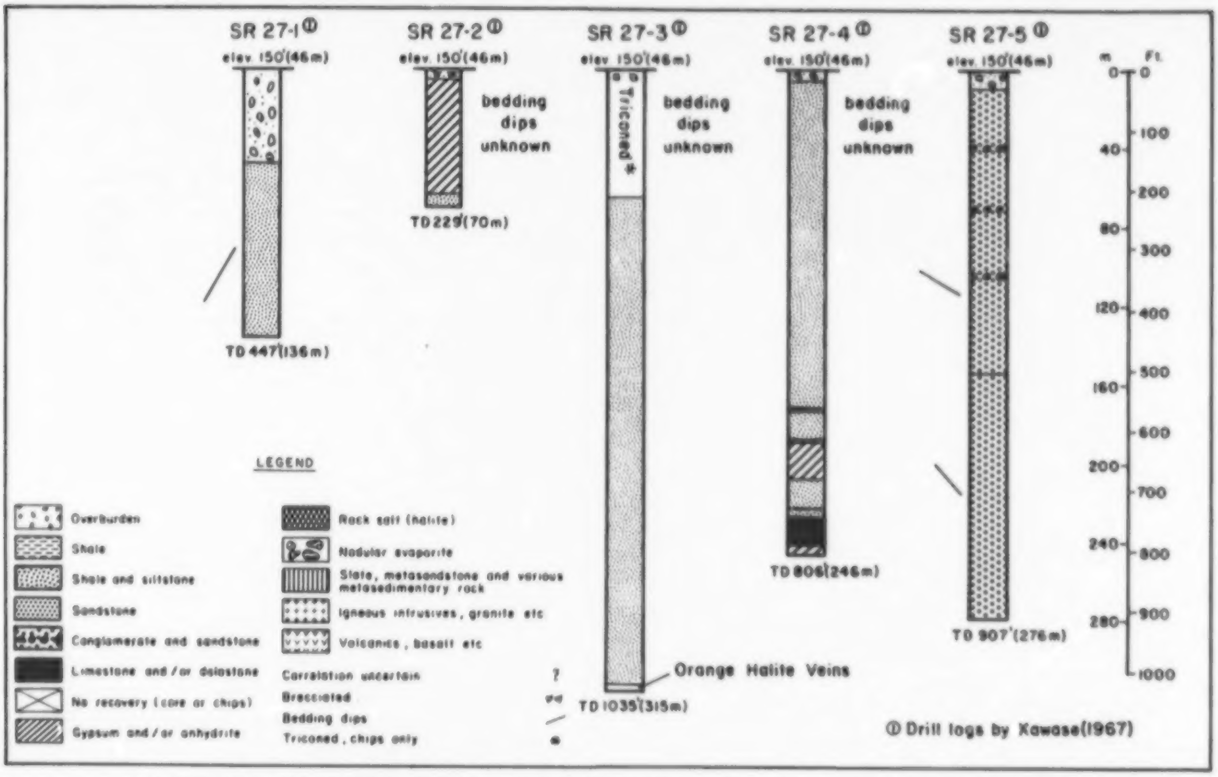

SR 27-1 ①
elev. 150'(46m)
TD 447'(136m)
SR 27-2 ①
elev. 150'(46m)
bedding dips unknown
TD 229'(70m)
SR 27-3 ①
elev. 150'(46m)
Triconed *
bedding dips unknown
Orange Halite Veins
TD 1035'(315m)
SR 27-4 ①
elev. 150'(46m)
bedding dips unknown
TD 806'(246m)
SR 27-5 ①
elev. 150'(46m)
TD 907'(276m)
m
Ft.
0
40
80
120
160
200
240
280
0
100
200
300
400
500
600
700
800
900
1000
① Drill logs by Kawase(1967)
LEGEND
Overburden
Shale
Shale and siltstone
Sandstone
Conglomerate and sandstone
Limestone and/or dolostone
No recovery (core or chips)
Gypsum and/or anhydrite
Rock salt (halite)
Nodular evaporite
Slate, metasandstone and various metasedimentary rock
Igneous intrusives, granite etc
Volcanics, basalt etc
Correlation uncertain ?
Brecciated
Bedding dips
Triconed, chips only *

Figure 4-3. Drillhole profiles, Beckwith occurrence, with legend for Cumberland drillhole profiles.

the Malagash area (Sheets 60 and 61) was mapped by Faribault and Fletcher (1905). A torsion balance gravimetric survey of the Malagash Mine area to assess the salt was undertaken by Miller for the Dominion Observatory and the Geological Survey of Canada in 1934. The basic stratigraphy and major structural forms were outlined and indicated the Malagash Penninsula had the form of an anticline with a core unit of what was described as "Carboniferous Limestone" (Windsor Group). Cameron (1965a,b,c; and 1967) remapped and compiled the geology in the Wallace-Malagash area as part of the 1966 Potash Project. A preliminary geological map was produced and is used as a base for Figure 4-5. This map also includes data compiled from Bell's (1944) maps of the Wallace River, Lazy Bay and Stake Road areas.

The geology of the area was also studied by Hayes (1920) who described the Malagash salt deposit stratigraphy and structure. Hayes (1920) recognized three basic rock units comprising the Malagash Anticline. The oldest, that forms the core of the structure, is the conglomerate, sandstone, shale, gypsum and salt of the "Mississippian Windsor Series". The Windsor limestone and gypsum rocks are intermittently exposed along the Northumberland Strait shore to the north of the Malagash Salt Mine shaft (Fig. 4-5). At one location, Hayes (1920) reported an overturned anticlinal fold limb with 300 feet of stratigraphic section exposed. Hayes (1920) reported fossils collected from a small and poorly preserved limestone in this vicinity were provisionally identified by Kindle as *Productus cf. cora*, *Martina anna* and *Aviculopecten cf. simplex*. The Windsor beds trend parallel to the east-west strike of the shoreline and dip steeply (overturned) to the south. Salt with gypsum was intersected in the Malagash Mine shaft in the central part of the structure. The evaporite unit here strikes generally east-west although bedding dips are variable from 25° south to 80° north over small horizontal distances (15 m). These highly variable dips are probably due to the severe deformation associated with evaporite flowage during the development of the Malagash Anticline (Fig. 4-6).

The "Windsor Series" is overlain with unconformity by a map unit referred to by the early workers as Late Carboniferous, "Millstone Grit", comprising conglomerate, sandstone and shale (Claremont and Middleborough of Bell, 1944). Hayes (1920) reported that this unconformity is exposed along the northern shore of the Malagash Penninsula over a distance of 1 km eastwards from Grindstone Point (near Gravois Point). The Windsor rocks at this locality are reported to be overturned and dip south and are unconformably overlain by "Millstone Grit" strata dipping north. The "Millstone Grit" has a basal member, of reddish brown conglomerate of which 239.3 m

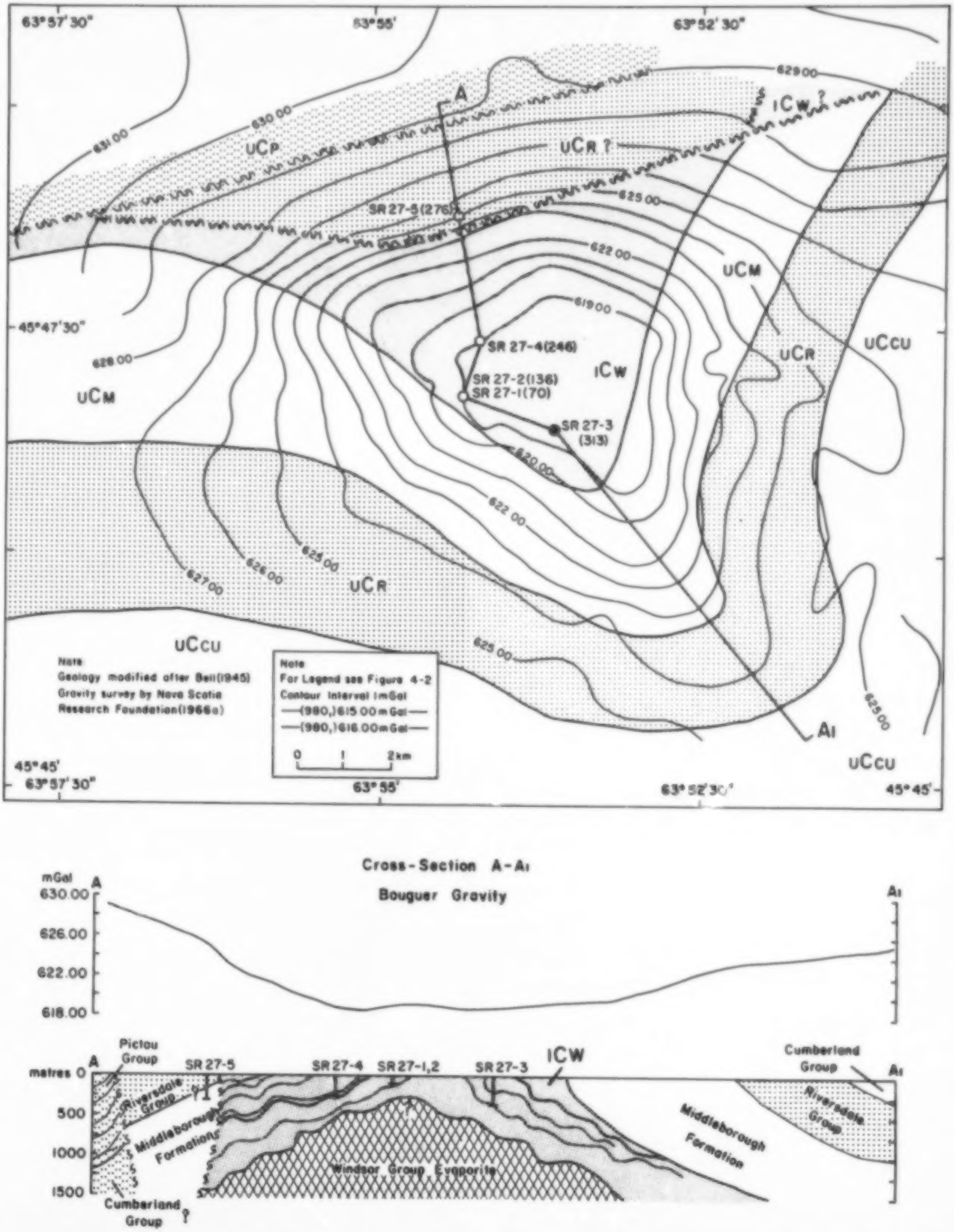

63°57'30"
63°55'
63°52'30"
45°47'30"
45°45'
45°45'
A
A1
uCP
uCR ?
lCW ?
uCM
uCR
uCCU
lCW
SR 27-5(276)
SR 27-4(246)
SR 27-2(136)
SR 27-1(70)
SR 27-3
(313)
631.00
630.00
629.00
628.00
627.00
626.00
625.00
622.00
620.00
619.00
Note
Geology modified after Bell(1945)
Gravity survey by Nova Scotia Research Foundation(1966a)
Note
For Legend see Figure 4-2
Contour interval 1mGal
—(980,)615.00mGal—
—(980,)616.00mGal—
0
1
2km
Cross-Section A-A1
Bouguer Gravity
mGal
630.00
626.00
622.00
618.00
metres 0
500
1000
1500
Pictou Group
Riversdale Group
Middleborough Formation
Cumberland Group
Windsor Group Evaporite
SR 27-5
SR 27-4
SR 27-1,2
SR 27-3
lCW
Cumberland Group
Riversdale Group
Middleborough Formation
?

Figure 4-4. Bouguer gravity and geological map with accompanying cross-section, Beckwith occurrence.

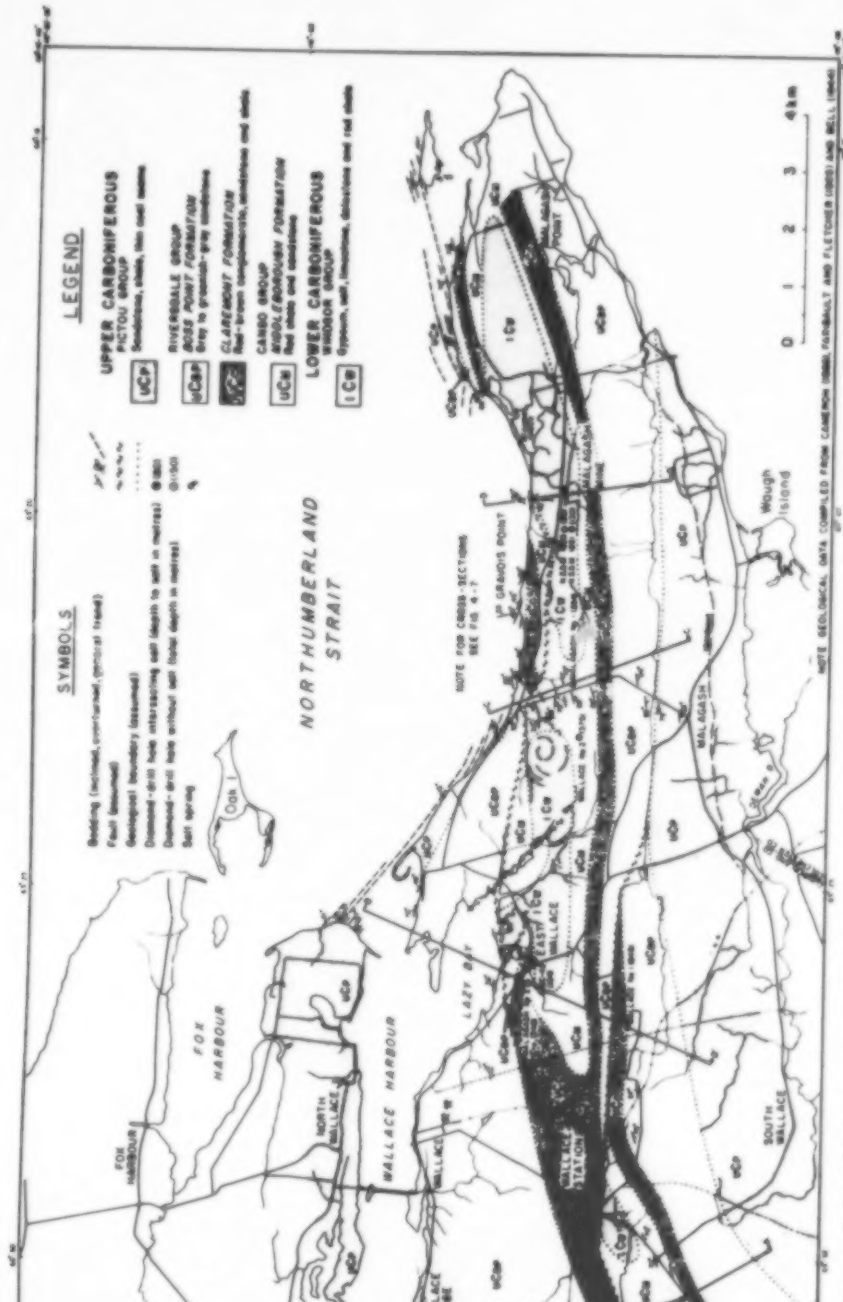

LEGEND
UPPER CARBONIFEROUS
PICTOU GROUP
uCp
RIVERSDALE GROUP
BOSS POINT FORMATION
uCbp
CLAREMONT FORMATION
CANSO GROUP
MIDDLEBOROUGH FORMATION
uCm
LOWER CARBONIFEROUS
WINDSOR GROUP
lCw
SYMBOLS
NORTHUMBERLAND STRAIT
Oak I.
NOTE FOR CROSS-SECTIONS SEE FIG 4-7
FOX HARBOUR
WALLACE HARBOUR
LAZY BAY
NORTH WALLACE
WALLACE
WALLACE STATION
EAST WALLACE
WALLACE BRIDGE
SOUTH WALLACE
MALAGASH
MALAGASH POINT
GRAVOIS POINT
Waugh Island
STONEHOUSE
0 1 2 3 4 km

Figure 4-5. Geological compilation map, Wallace-Malagash area, Cumberland County.

(785 ft.) are exposed west of Gravois Point and 221 m (725 ft.) are exposed at Malagash Point. The younger units of his "Millstone Grit" are reported to be more variable and include thickly bedded grey-green sandstone, brown and green shale interbeds and grit-conglomerate beds. Three nonfossiliferous blue limestone beds are included in this unit. The total minimum thickness is in excess of 762 m (2500 ft.)

The "Millstone Grit", according to Hayes (1920), is overlain with unconformity by the Late Carboniferous or Early Permian "New Glasgow Series", comprising conglomerate, sandstone and shale (Pictou Group of Bell, 1944).

The Carboniferous stratigraphy of northern Nova Scotia was redefined by Bell (1944) in terms of rock stratigraphic groups related to his originally defined biostratigraphic units. This redefinition was required due to the variable nature of a given lithological succession. Bell (1944) considered his groups to represent an assemblage of strata in which no major breaks of deposition had been detected, and which contain a fossil flora and fauna of a specific time interval. Bell's (1944) terminology is the basis of the present nomenclature of the Carboniferous succession and include, from base to top, Horton, Windsor, Canso, Riversdale, Cumberland, and Pictou Groups.

Bell (1944) applied the revised nomenclature to the Malagash Anticline. The "Carboniferous Limestone" map unit of Faribault and Fletcher (1905), is referred to by Bell (1944) as the Windsor Group. The overlying conglomerate and sandstone unit Faribault and Fletcher (1905) mapped as the "Millstone Grit" is termed as two units. Bell (1944) reported that faulting brought the Windsor Group salt zone into contact on the southern side of the Malagash Anticline with Claremont Formation conglomerate: on the northern side with Claremont Formation conglomerate or Middleborough Formation: on the west, with the Middleborough Formation (Canso Group?); and on the east, with beds of the Windsor Group younger than the salt. An overturned section exposed to the north of the deposit (presumably that previously described by Hayes, 1920) Bell (1944) reported as containing Claremont and Boss Point Formations of the Riversdale Group which are unconformably overlain by northerly dipping beds of the Pictou Group ("New Glasgow Series" map unit of Faribault and Fletcher, 1905).

Structural Configuration

The structural configuration of the Malagash structure has been described and interpreted by many investigators. A summary of these will be presented in the following paragraphs. With the development of the underground workings in the Malagash Salt Mine, the three dimensional subsurface attributes of the structure were realized in greater detail. Hayes (1920) concluded:

> The salt at Malagash occurs as a stratified deposit interbedded with rocks of the Mississippian (Lower Carboniferous) period and apparently forms an integral portion of the Windsor (Carboniferous) Limestone series.
>
> The Malagash salt horizon lies along the axis of an anticlinal fold, and may, therefore, be crumpled locally and perhaps thickened by isoclinal folding and duplication of strata.
>
> The dimensions of the salt deposit can only roughly be approximated .... Assuming that the beds have not been duplicated by folding or deleted by faulting the actual thickness of the original beds is probably more than 300 feet, and less than 500 feet, measured at right angles to the dip.
>
> The salt strata are probably offset by faults at certain localities, but the regularity of the strata along the coast to the north, for a distance of about three-quarters of a mile, suggests that the salt may extend without serious interruption for an equal distance along the strike, and the sedimentary character of the salt points continuation in depth parallel to the dip of the enclosing rocks.

Ellsworth (1926) reported (extracted below) that Hayes' (1920) prediction of "local crumpling" was verified by mining operations, to a depth of 200 feet.

> The steeply inclined bed which supplies the present high-grade product has been folded almost into a horseshoe shape and minor faulting, crumpling, thickening, thinning, and duplication of beds occur in extreme degree. The structures indicate that the salt body has been subjected to at least two major external deformative forces which have acted in directions more or less at right angles: the first, due to the anticlinal folding along an east and west axis, has probably squeezed the salt up into the crest of the anticline: the second, due to transverse faulting with accompanying or subsequent compressional stress in a direction approximately parallel to the anticlinal axis, has further folded and perhaps thickened it: and finally a possible lateral movement of the fault blocks may have introduced a shearing stress as a third component of the deformational forces. As a result of the combined action of these forces, the structure of the Malagash deposit in many respects resembles that of salt domes described in the literature, though it is not intended to imply that it is necessarily circular in outline or that the mass has risen any great distance, if at all from its point of origin, as is the case in many foreign examples. The extreme deformation and duplication of beds, the steep inclination of the strata, the location in the crest of an anticline, and the capping of residual gypsiferous material ... are cited by Hahn as characterisitic of salt domes in general ... there is no proof so far that the deposit ever actually penetrated through originally overlying rock formations. If, however, the lower part at least of the gypsiferous material capping

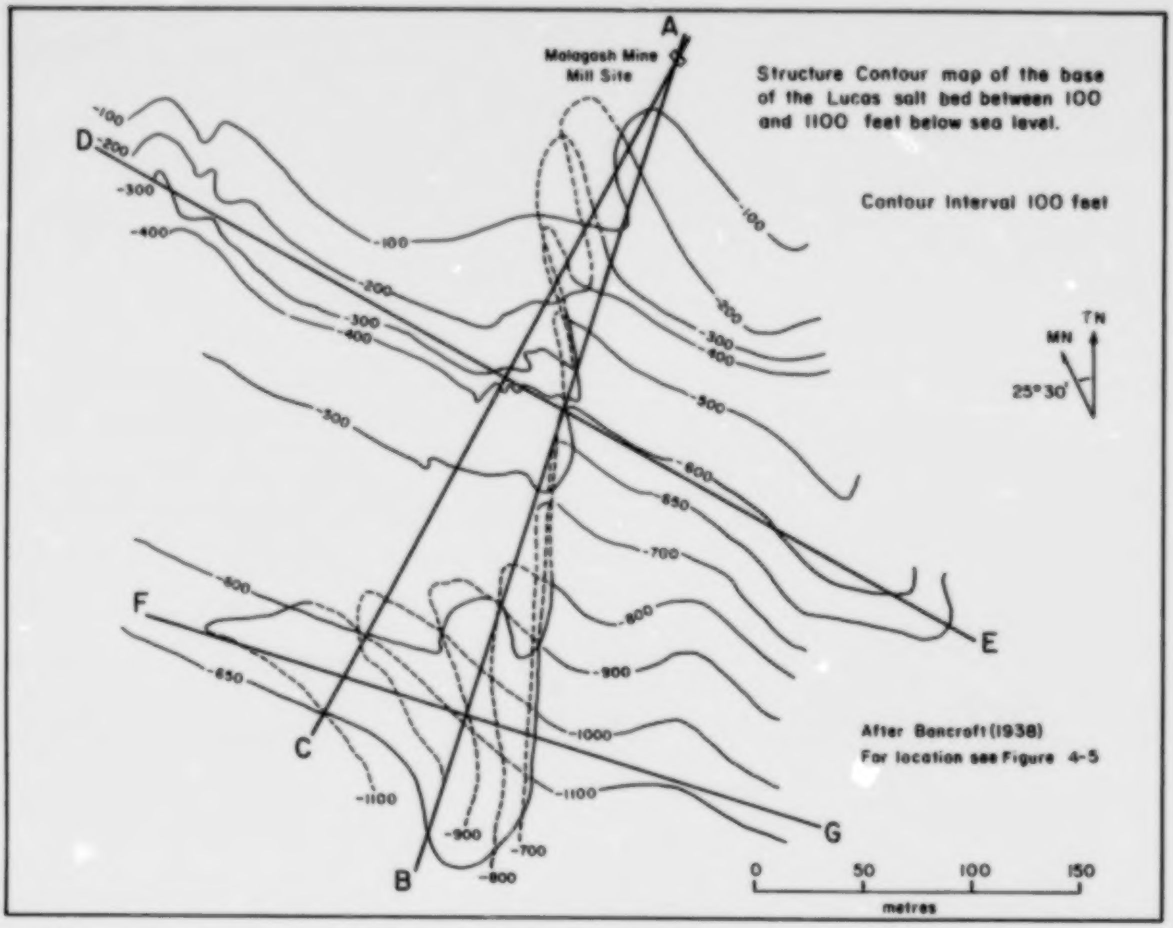

A
Malagash Mine Mill Site
Structure Contour map of the base of the Lucas salt bed between 100 and 1100 feet below sea level.
Contour Interval 100 feet
D
E
F
G
C
B
-100
-200
-300
-400
-500
-600
-650
-700
-800
-850
-900
-1000
-1100
TN
MN
25°30'
After Bancroft (1938)
For location see Figure 4-5
0
50
100
150
metres

Figure 4-6. Structure contour map on the base of the Lucas seam with accompanying sections, Malagash Mine.

the deposit is regarded as being residual insoluble material resulting from the leaching away of the original upper part of the salt, there would seem to be the possibility that the mass did originally penetrate the upper formations. .... a point worth noting which seems to support the idea that the Malagash salt body is to a certain extent dome-like in structure, is the fact that the rather detailed drilling exploration carried out by Sir Alexander McGuire farther to the west on the same anticlinal axes failed entirely to locate the salt horizon.

Hayes (1920) indicated that Sir Alexander MacGuire of London, England, was actively drilling in exploration for salt in the vicinity of Wallace in 1919.

Bancroft (1938) produced a structure contour map and cross-sections illustrating the structure encountered in the Malagash Mine (Fig. 4-6). The mapping was based on surveys of the Lucas salt bed which has a general strike of 115° and an average dip of 45° south. Minor folds occurring as welts and corrugations are found on the general strike and dip of the beds. Folds transverse to the trend of the beds are prominent in the structural mapping by Bancroft (1938). The folds are characterized by marked attenuation on the limbs and thickening in the hinge area. Cross-sections through this folding in the Lucas seam (Fig. 4-6) indicate the curvilinear fold axes trend approximately parallel to the general dip direction of the seam and vary in closure from open to subisoclinal and isoclinal.

Bell's (1944) discussion of the structure and stratigraphy of the Malagash deposit follows:

> It is sufficient to state that the salt deposit with its accompanying interbedded anhydrite lies in a fault block. G. W. H. Norman considers that the two faults that bound the deposit on the north and south respectively are thrust planes that "strike parallel to the anticlinal axis and dip inwards to converge towards one another at depth, as in many other typical salt structures. Many salt structures have an hourglass structure in which bounding walls converge for some distance with depth and then diverge" (Norman, 1941; personal communication).

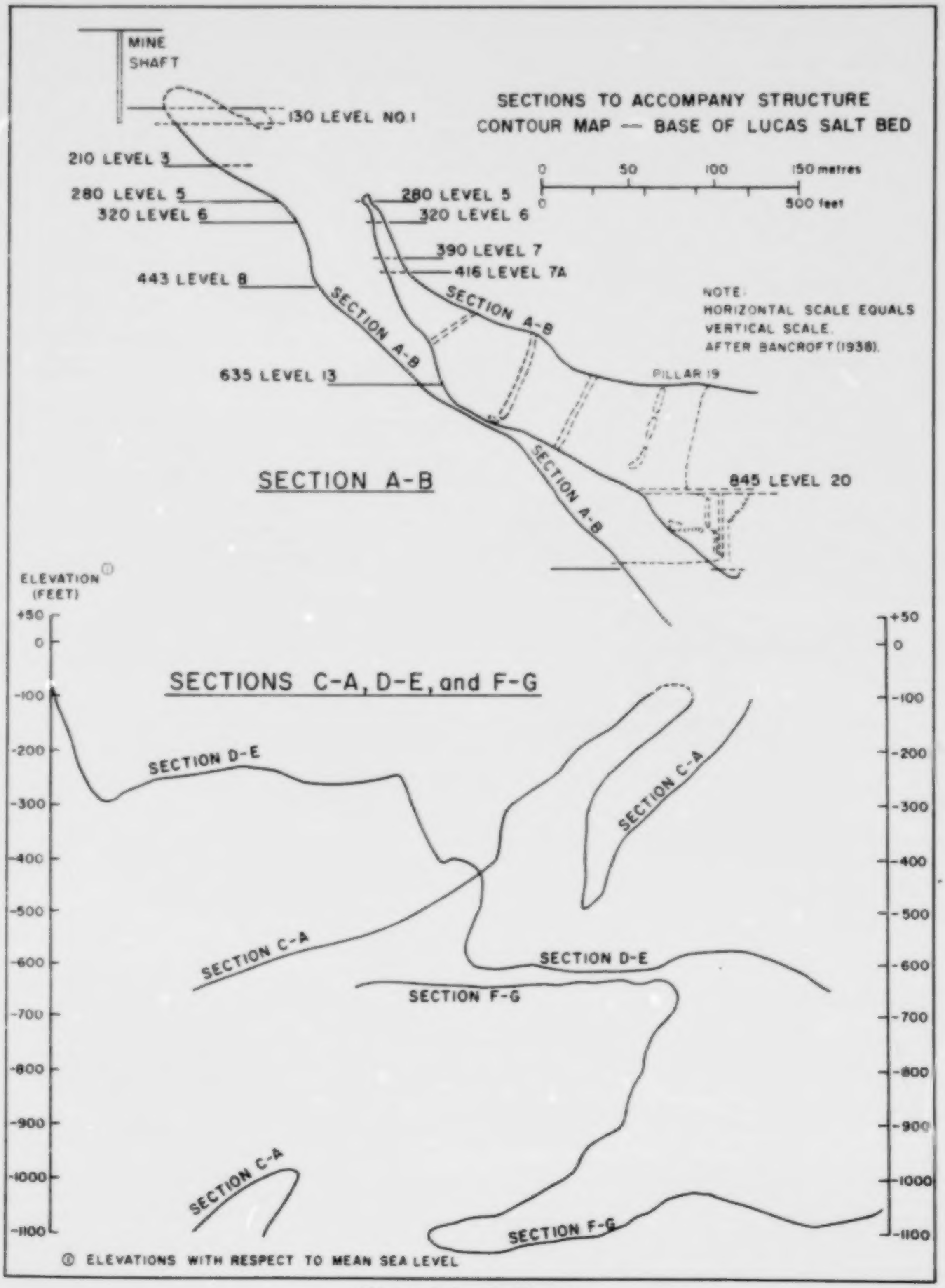

MINE
SHAFT
SECTIONS TO ACCOMPANY STRUCTURE
CONTOUR MAP — BASE OF LUCAS SALT BED
130 LEVEL NO.1
210 LEVEL 3
280 LEVEL 5
320 LEVEL 6
280 LEVEL 5
320 LEVEL 6
390 LEVEL 7
416 LEVEL 7A
443 LEVEL 8
635 LEVEL 13
845 LEVEL 20
PILLAR 19
SECTION A-B
SECTION A-B
SECTION A-B
SECTION A-B
0
50
100
150 metres
0
500 feet
NOTE:
HORIZONTAL SCALE EQUALS
VERTICAL SCALE.
AFTER BANCROFT (1938).
ELEVATION ①
(FEET)
+50
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
SECTIONS C-A, D-E, and F-G
SECTION D-E
SECTION C-A
SECTION C-A
SECTION D-E
SECTION F-G
SECTION C-A
SECTION F-G
① ELEVATIONS WITH RESPECT TO MEAN SEA LEVEL

Figure 4-6. Continued.

> It is inferred that the western boundary of the salt deposit is the transverse fault that may be seen at the shore about 450 feet northwest of the salt mine. The fault there is a normal fault with stratigraphic upthrow on the east side according to Norman, of 500 feet or more. The eastern boundary of the salt deposit is unknown, although it is seemingly also a fault.

The general structural configuration of the Malagash structure is illustrated in the "Stake Road Section" of Bell (1944) (Figs. 4-5 and 4-7). The Stake Road trends roughly north-south and has outcrops of the major rock units which define a cross-section through the Malagash Anticline. Bell (1944) indicated the following stratigraphic sequence in the southern limb of the Anticline in descending order:

> PICTOU GROUP: brownish red sandstone and shale; 1300+ feet thick

- - - - - - - - - - - fault - - - - - - - - - - -

> RIVERSDALE GROUP Boss Point Formation: grey sandstone, massive and flaggy, minor quartz-pebble conglomerate; 1500+ feet thick.
>
> Claremont Formation: brownish red arkose, arkosic sandstone and conglomerate with limy and kunkur nodular beds near base; 1800 ± feet thick

- - - - - - - - - - disconformity - - - - - - - - - -

> Middleborough Formation: finely micaeous and crossbedded, brownish red sandstone, siltstone, and shale; 1900± feet thick.

- - - - - - - - - - - fault? - - - - - - - - - -

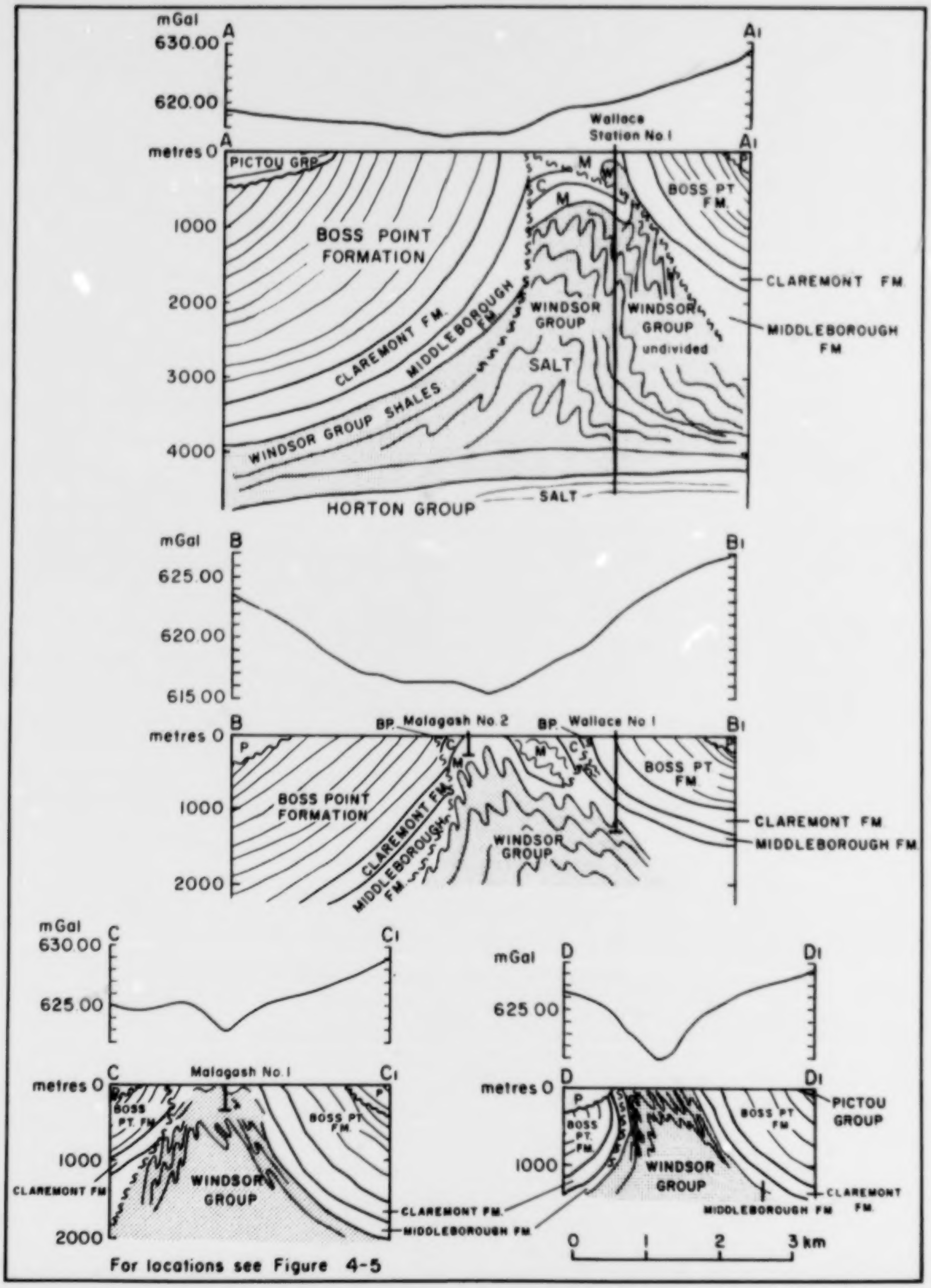
> WINDSOR GROUP: brownish red sandstone, siltstone, mudstone, and shale (based upon the presence of a gypsum? sinkhole, Fig. 4-5, Section C-C_1).

Bell (1944) expressed some reservation about the certainty of the presence of Windsor strata along the Stake Road (based upon a small sink hole). He stated, however, that on the evidence of large (gypsum) sinkholes, it is definitely present one half mile southwest of the smaller suspected sinkhole. Gypsum is also reported by Bell (1944) to outcrop one half mile farther west. To the east of the Stake Road, Bell (1944) reported the Middleborough Formation overlain unconformably by Pictou Group strata. Windsor strata have not been established at surface in the area to the east of the Stake Road except for the western end of the Malagash Salt Mine area. Middleborough Formation strata apparently occupy the axial area between the eastern and western Windsor outcrop areas.

In 1966 the Nova Scotia Department of Mines and Nova Scotia Research Foundation undertook a potash exploration survey in the Malagash-Wallace area. The potash assessment involved geological mapping (Fig. 4-5) and geophysical surveys including detailed gravity (Fig. 4-8) and total intensity magnetometer (Fig. 4-9). These surveys were followed by diamond-drill exploration of selected targets. The first hole, Malagash No. 1 (Fig. 4-10), was drilled at the western end of the Malagash Mine, eastern Windsor Group outcrop area. The hole collared in the Middleborough Formation penetrated Windsor Group gypsum at 224 m (734 ft.) and intersected salt from 264 m (865 ft.) to a total depth of 306 m (1004 ft.). The overlying Middleborough Formation, comprising red shale and sandstone, are very steeply dipping (65° to 80°) and are extensively brecciated. The Windsor Group gypsum is indicated to be less steeply dipping (20°-40°) and is apparently in fault contact at a depth of 224 m with the Middleborough Formation.

The Windsor outcrop area south of Wallace was explored with four drillholes. Wallace No. 2 (Fig. 4-11) was drilled near the eastern terminus of the Windsor outcrop area and penetrated two separate salt intervals, 372-542 m (1221-1778 ft.) and 756-798 m (2482-2618 ft.), before it was abandoned at a depth of 798 m (2618 ft.). Bedding dips in the cored intervals of the hole are reported to be moderate (20-40°). Since only the salt intervals were cored, the dips of the sandstone and shale intervals are not known, and the effects of brecciation and faulting are not determinable. It is probable that faulting and possibly folding are responsible for the occurrence of two salt horizons. Numerous thin low grade potash mineralized intervals are found in the salt-shale breccia intervals of Wallace No. 2 (Fig. 4-11). The western terminus of the outcrop area was tested by the Malagash No. 2 diamond-drill hole. Malagash No. 2 intersected brecciated Windsor Group gypsum, anhydrite, and green-grey brecciated mudstone-siltstone to a depth of 171.3 m (562 ft.) where sandstone and siltstone were penetrated to a final total depth of 248 m (814 ft.) (Fig. 4-10). These lower sandstones are reported to be similar to the rocks of the Middleborough Formation exposed on Wallace River. If this is the case, then the section is stratigraphically out of order, and is attributable to either overfolding and/or thrust faulting. Bell (1944), in a possibly analogous situation, indicated overthrusting of Windsor in the Wallace River section to the west (Figs. 4-5, 4-7). He described the geology in East Wallace area from exposure on the southern shore of Lazy Bay and nearby stream outcrops (Fig. 4-12) as follows:

> This area lies west of the Stake Road to East Wallace settlement. It is crossed by Wade Brook, in the lower part of which the presence of the Windsor group is attested by gypsum sinks. It contains also the outcrop of gypsum east of Wade Brook already noted in discussion of the Stake Road section. From this outcrop northwesterly almost to the shore at East Wallace, a distance of about 8000 feet, there are no known outcrops of Windsor strata. The gypsum east of Wade Brook dips at a high angle (up to 65 degrees) southerly and obviously lies in the south limb of the Malagash anticline. Overlying strata of the Middleborough formation, consisting of brownish red, finely micaceous sandstone, siltstone, and shale, outcrop on Wade Brook southwest of the gypsum, striking about 15 degrees south of east and dipping 75 degrees south. Whether they overlie the gypsum unconformably or are separated by a fault is unknown.


mGal
630.00
620.00
A
A1
Wallace Station No.1
metres 0
1000
2000
3000
4000
PICTOU GRP
BOSS POINT FORMATION
CLAREMONT FM.
MIDDLEBOROUGH FM.
WINDSOR GROUP SHALES
WINDSOR GROUP
SALT
WINDSOR GROUP undivided
BOSS PT FM.
CLAREMONT FM.
MIDDLEBOROUGH FM.
HORTON GROUP
SALT
M
C
S
mGal
625.00
620.00
615.00
B
B1
BP.
Malagash No.2
BP.
Wallace No.1
metres 0
1000
2000
P
BOSS POINT FORMATION
CLAREMONT FM.
MIDDLEBOROUGH FM.
WINDSOR GROUP
BOSS PT FM.
CLAREMONT FM.
MIDDLEBOROUGH FM.
mGal
630.00
625.00
C
C1
Malagash No.1
metres 0
1000
2000
BOSS PT. FM.
BOSS PT FM.
CLAREMONT FM
WINDSOR GROUP
CLAREMONT FM.
MIDDLEBOROUGH FM.
mGal
625.00
D
D1
metres 0
1000
P
BOSS PT. FM.
WINDSOR GROUP
BOSS PT FM.
PICTOU GROUP
CLAREMONT FM.
MIDDLEBOROUGH FM
0
1
2
3 km

For locations see Figure 4-5

Figure 4-7. Geological and Bouguer gravity cross-sections, Malagash deposit.

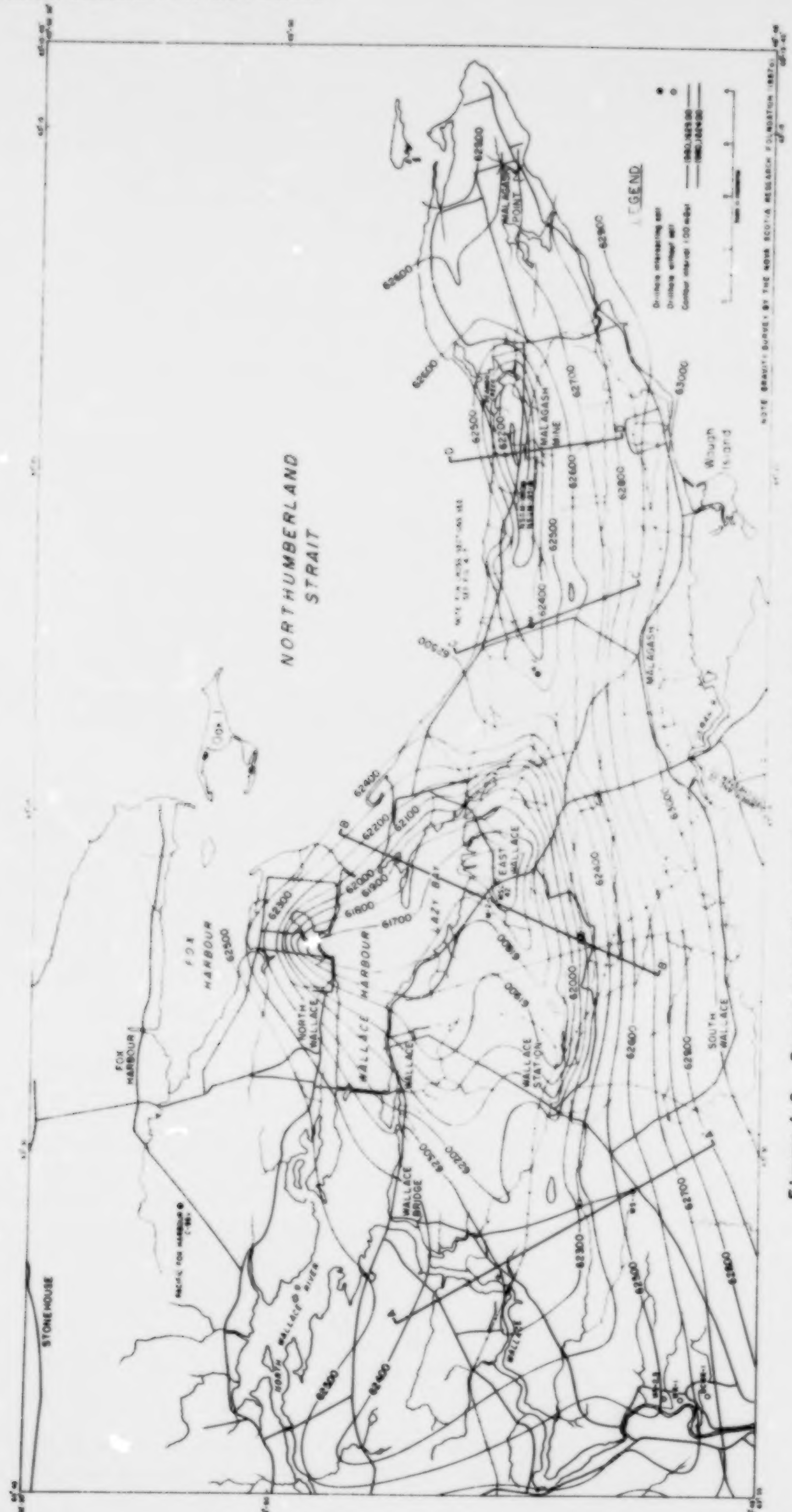

NORTHUMBERLAND STRAIT
FOX HARBOUR
FOX HARBOUR
NORTH WALLACE
WALLACE HARBOUR
LAZY BAY
EAST WALLACE
WALLACE
WALLACE STATION
SOUTH WALLACE
WALLACE BRIDGE
WALLACE RIVER
STONEHOUSE
MALAGASH MINE
MALAGASH POINT
MALAGASH
Waugh Island
LEGEND
61600
61700
61800
61900
62000
62100
62200
62300
62400
62500
62600
62700
62800
62900
63000
63100

Figure 4-8. Bouguer gravity anomaly map, Wallace-Malagash area, Cumberland County.

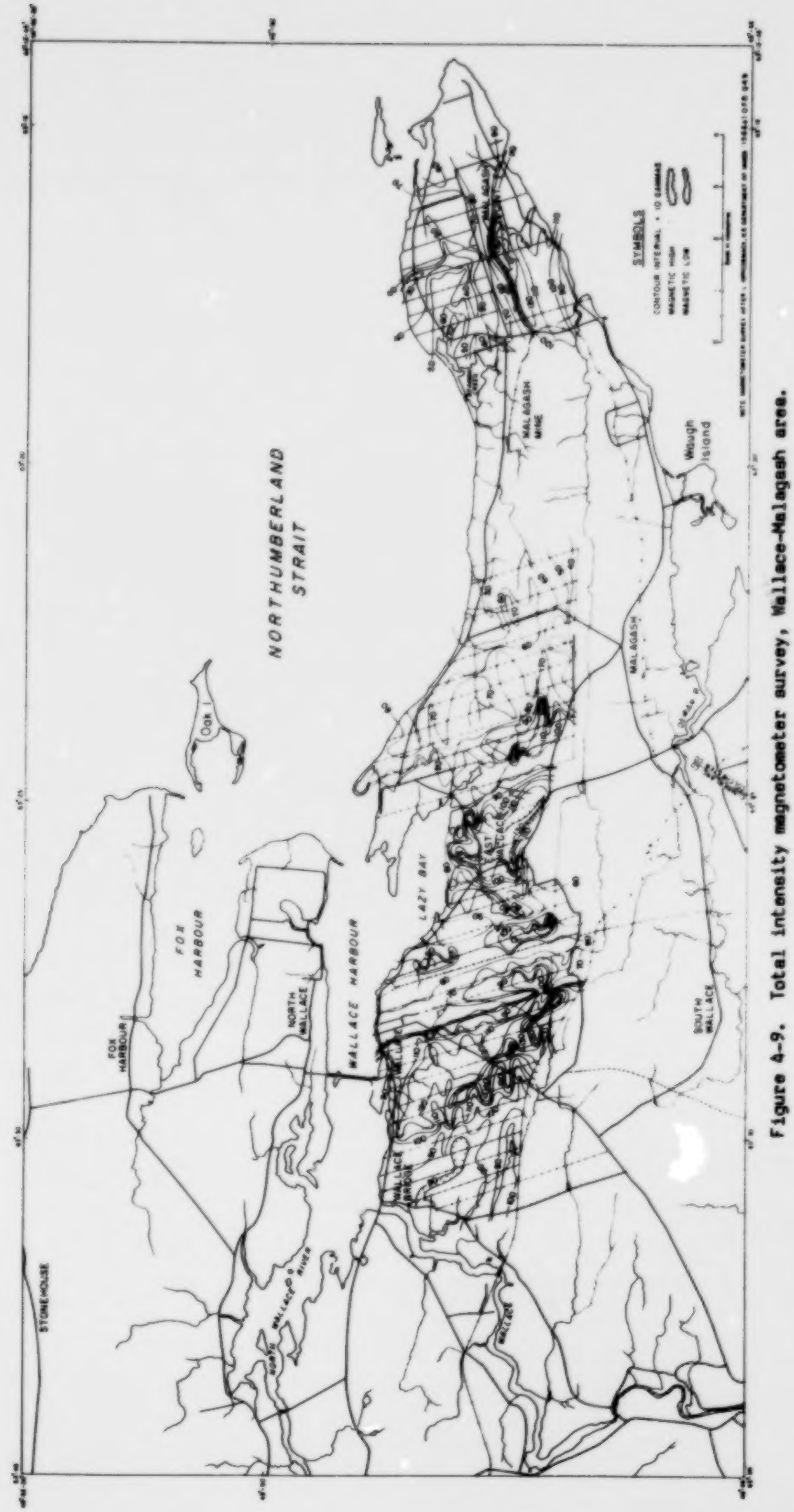

NORTHUMBERLAND STRAIT
Oak I.
FOX HARBOUR
FOX HARBOUR
NORTH WALLACE
WALLACE HARBOUR
LAZY BAY
WALLACE HARBOUR
EAST WALLACE
STONEHOUSE
NORTH WALLACE RIVER
WALLACE
SOUTH WALLACE
MALAGASH
MALAGASH MINE
Waugh Island
SYMBOLS
CONTOUR INTERVAL = 10 GAMMAS
MAGNETIC HIGH
MAGNETIC LOW

Figure 4-9. Total intensity magnetometer survey, Wallace-Malagash area.

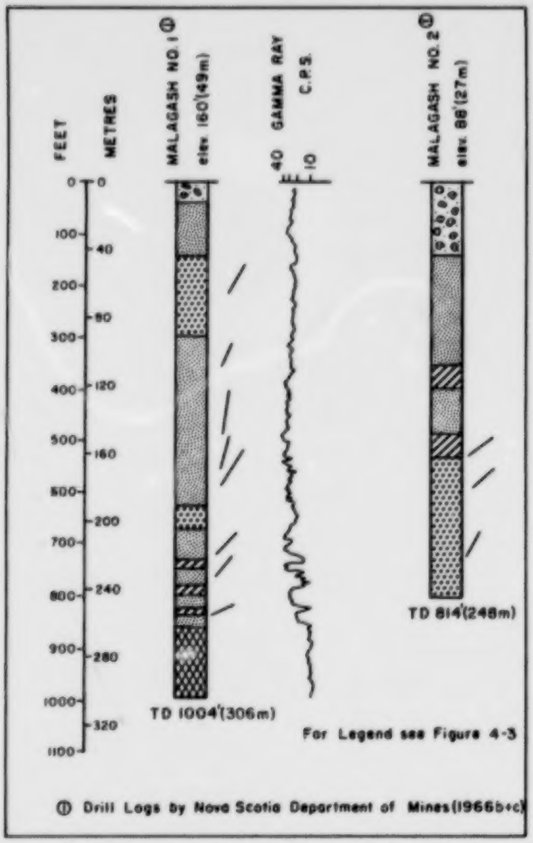


Figure 4-10. Drillhole profiles Malagash Nos. 1 and 2, Malagash deposit. (For locations see Fig. 4-5).

Outcrops on the shore west of Wade Brook near East Wallace show the strata there belong to the northern limb of the anticline. The Windsor group is interpreted to lie in a fault block upthrust into the Boss Point formation. Two main faults, which bound the Windsor group, are believed to be present at the shore. The main one strikes roughly parallel to the shore in a direction north 81 degrees east, from which a branch diverges in a direction south 60 degrees east. If these faults extend eastward to meet the southwesterly trending fault in the northern part of the Stake Road section the Windsor strata in the East Wallace area lie in a wedge shaped fault block, obliquely transversing the Malagash anticline.

Windsor rock exposed in the vicinity of East Wallace is mainly gypsum, which, near the faults, carries large amounts of secondary selenite. One band of calcareous or dolomitic shale, overturned at a high angle southwestward, carries Productus lyelli Verneuil, Leptodesma dawsoni (Beede), Modiola dawsoni (Bell), and cephala of a xiphosurid, indicative of a Lower Windsor age. The Boss Point strata into which the Windsor beds have been thrust consist of grey sandstone, much shattered near the faults, brownish red shale, and at least one bed of quartz-pebble conglomerate. These strata are underlain near the main highway (route 6) by beds of the Claremont formation, comprising brownish red, arkosic conglomerate, red sandstone, and shale, dipping 40 to 60 degrees northeasterly.

It is evident from Bell's (1944) descriptions that the rocks in the structure have been subjected to extensive deformation involving faulting, folding and overturning.

Wallace No. 1 (Fig. 4-11) was drilled 1.9 km south-southwest of Wallace No. 2 on a structurally separate block (Fig. 4-5). This block is apparently separated from the Wallace-Malagash block by an east-west trending fault (Cameron, 1967). Wallace No. 1 penetrated a thick section of conglomerate and sandstone from 43 m (140 ft.) to approximately 633 m (2077 ft.) (Claremont Formation); an interval of reddish brown, and grey green siltstone and sandstone with dips of 30-45° was intersected to 823 m (2700 ft.) (Middleborough Formation); grey shale was intersected to 845 m (2772 ft.) where the Windsor Group salt was penetrated. The hole was stopped in salt at a depth of 1222.6 m (4011 ft.) and potash mineralized intervals were associated with the salt. Wallace No. 1 intersected 29.9 m (98.2 ft.) of 5.05% K_2O at a depth of 1180 m (3870 ft.). Dips in the salt interval are moderate to steep in the range of 45° to 60°.

Wallace No. 1 was apparently drilled on the southerly dipping flank of the anticlinal structure (Fig. 4-5) and does not appear to have any repetition of strata (overlying the salt) by faulting or folding. Since most of the upper section was not cored, overturning and repetition may occur. The nature of the fault separating the blocks is not certain although both steeply dipping strike and dip slip (reverse) movements are inferred, but dip direction is not discernible and may change with depth.

Bell (1944), described the section exposed on the Wallace River approximately 4 km west of Wallace Station No. 1 as the best exposed section through the Malagash-Claremont Anticline. The sequence in descending order is summarized as follows:

PICTOU GROUP (may include some Cumberland)
    North limb
        brownish red sandstone, siltstone, brownish red and some grey arkosic grit and conglomerate; 1500 feet underlain by brownish red and mottled red and grey sandstone and grey quartzite-pebble conglomerate. Thickness: 825 feet.

    South limb
        lower half, grey and brownish red quartzite-pebble conglomerate and sandstone; and upper half, mainly brownish red, arkosic conglomerate, sandstone and grit. Thickness 1785 ft.

disconformity

RIVERSDALE GROUP

Boss Point Formation
grey and brownish red sandstone, lenticular limestone conglomerate beds. Thickness: 3600 feet, north limb; 4350 feet, south limb

Claremont Formation
brownish red to brick red arkosic conglomerate, some red sandstone and kunkur bearing shale.
Thickness: 450-500 feet.
Fault in north limb, disconformity in south limb

Middleborough Formation
brownish red sandstone, siltstone and shale. Thickness: 275 feet, north limb; 3175 feet, south limb. Fault in north limb, possible fault or disconformity in south limb.

WINDSOR GROUP
Poorly exposed, yellowish brown and grey, calcareous sandy shale, shaly limestone. Thickness: uncertain.

This section (Fig. 4-12) is probably typical of a higher erosional level, or lower level of intrusion in the Malagash Anticline with the mobile Windsor core not fully exposed. The Wallace River section was generally confirmed in later drilling along strike to the east near Wallace station.

In 1973 Anschutz Corporation drilled Wallace Station No. 1 in exploration for petroleum, 2.5 km southwest of Wallace Station and 5 km west-southwest of Wallace No. 1 on the Wallace structural block of the Malagash Anticline (southern limb) (Figs. 4-5, 4-13). The following is the generalized stratigraphic succession reported in the well: surface to 134 m (440 ft.) Middleborough Formation; 134-491 m (440-1610 ft.) Windsor Group; reverse fault; 491-613 m (1610-2010 ft.) Claremont Formation; 613-792 m (2010-2600 ft.) Middleborough Formation; 792-2455 m (2600-8056 ft.) Windsor Group C? Subzone; 2455-2506 m (8056-8222 ft.) Windsor Group B? Subzone; 2506-3981 m (8222-13,060 ft.) Windsor Group A? Subzone (salt); 3981-4267 m (13,060-14,000 ft.) Windsor Group shale and chert; 4267-4536 m (14,000-14,883 ft.) Horton Group. The interval 4432-4536 m (14,540-14,883 ft.) in the Horton Group is reported to contain 51% salt. Drilling difficulties required multiple directional redrilling resulting in a rather complex well history.

A southward dipping thrust fault was postulated by MacDonald (1973) to explain the Middleborough Formation-Windsor Group section to 491 m overlying the younger Claremont Formation. Anomalous K_2O measurements are indicated in several intervals of the salt although analyses of sidewall core from these intervals did not indicate a correlation with potash minerals.

Malagash Mine

The geology of the Malagash Mine site has been described by various workers including Hayes (1920, 1931), Ellsworth (1926), Chambers (1924), Norman (1932b), Bancroft (1938), Messervey (1950) and MacQuarrie (1975). Detailed descriptions of the mine are found in these reports and only a general description is summarized in the following paragraphs.

The Malagash Mine shaft is located 550 m south of the Northumberland Strait Shore on the southern limb of the Malagash Anticline (Figs. 4-5, 4-6, 4-14 and 4-15). The salt occurs as complexly deformed, variably thick, steeply dipping beds interstratified with gypsum and anhydrite. The rock salt is reported to have a distinct 5 cm thick banded structure with colours ranging from pure white to very dark grey with bands of red occurring locally. Insoluble material such as anhydrite, gypsum and clay occur as broken beds, stringers and irregular patches that originally were probably interstratified with the halite, but through deformation became broken and mixed in the mass. The mine is reported to have operated on three main salt seams, the MacKay, the Chambers, and the Lucas seams. The major salt production in the mine has come from the Lucas seam which is made up of three beds: a lower one consisting of pure white crystalline halite, a middle bed of interstratified salt, gypsum and anhydrite, and an upper bed of crystalline white halite with interstratified dark salt bands. The MacKay seam is reported to have inconsistent salt quality. The Lucas seam bed has a general strike of 115° and has an average dip of 45° south.

Extensive plastic deformation involving complex folding was prevalent in the mine (Fig. 4-6). Hayes (1920) postulated that strata duplication by folding or deleted by faulting probably existed in the salt mass. Later mine development substantiated that local crumpling, attenuation and thickening accompanied by complex isoclinal folding was present. Folding of the deposit is responsible for variations in the salt seam thicknesses making mine workings somewhat erratic (Fig. 4-14 and 4-15) because they had to follow the salt in the deformed beds. A large number of diamond-drill holes were drilled to explore and develop the Malagash Mine deposit (Fig. 4-16).

The Malagash Salt Mine was worked using an open stope system. A longwall cutting machine undercut the salt seam before blasting. This method was used until the dip of the seam became too steep at depth, and the undercutting procedure was abandoned. Mining width averaged 1.8 m (6 ft.) and had a maximum width of 3.7-4.3 m (12-14 ft.). Drilling underground was done with both electric and compressed air drills. The salt that required beneficiation was treated through flotation and fusion processes. Brining operations involving water sprayed on the salt were carried out on part of the MacKay seam. More detailed descriptions of the mining methods and development history are found in Hayes (1931), MacQuarrie (1975) and in Nova Scotia Annual Reports on Mines for the period in which the mine operated.

GEOPHYSICS

Miller and Norman (1936) published the results of a torsion balance gravimetric survey of the Malagash salt deposit. A substantial gravity

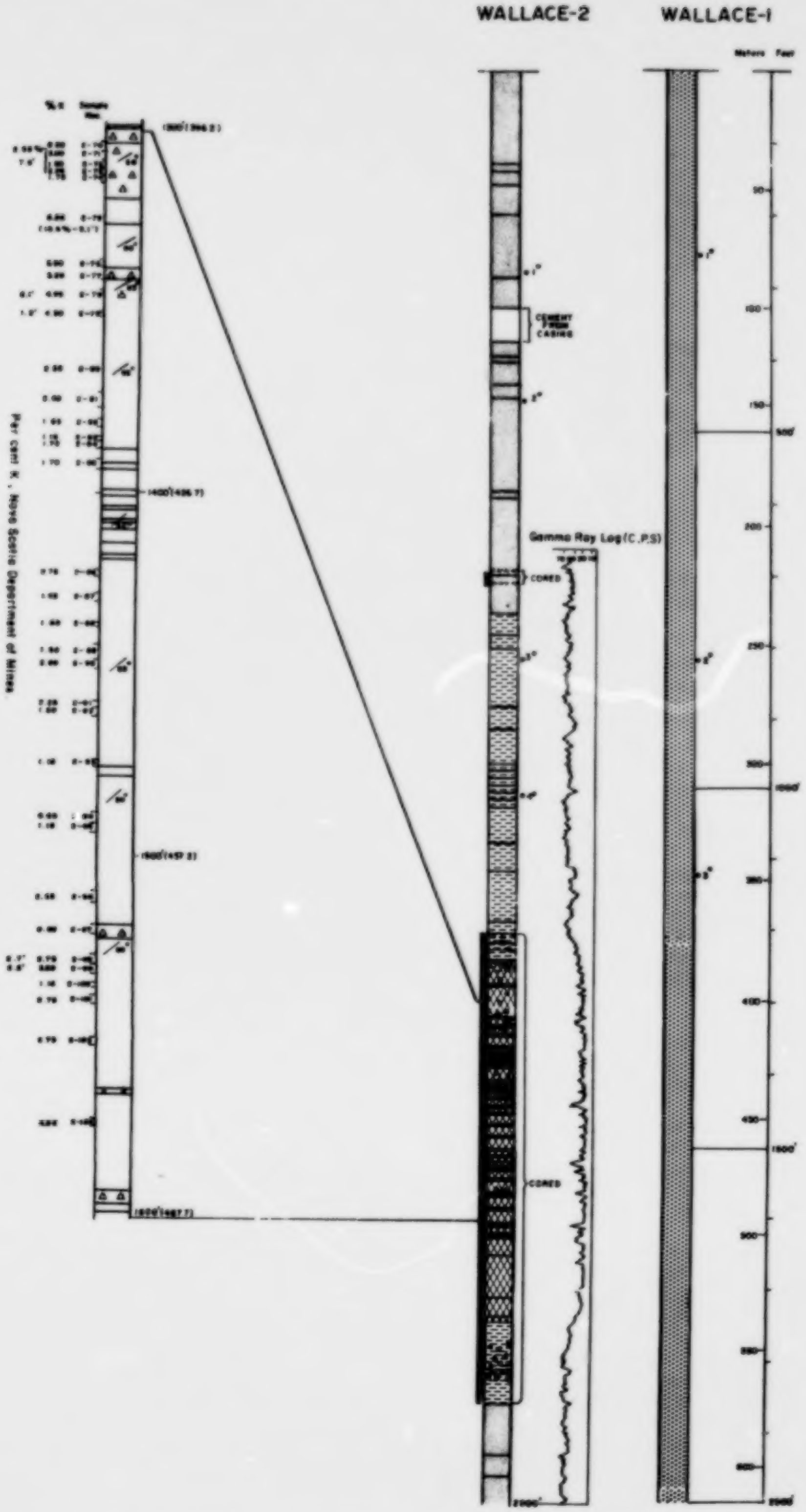

WALLACE-2
WALLACE-1
Metres
Feet
%K
1300'(396.2)
1400'(426.7)
1500'(457.2)
1600'(487.7)
Per cent K, Nova Scotia Department of Mines
CEMENT FROM CASING
CORED
CORED
Gamma Ray Log (C.P.S)
50
100
150
200
250
300
350
400
450
500
550
600
500'
1000'
1500'
2000'
2000'

Figure 4-11. Drillhole profiles, Wallace Nos. 1 and 2, Malagash deposit. (For locations see Fig. 4-5).

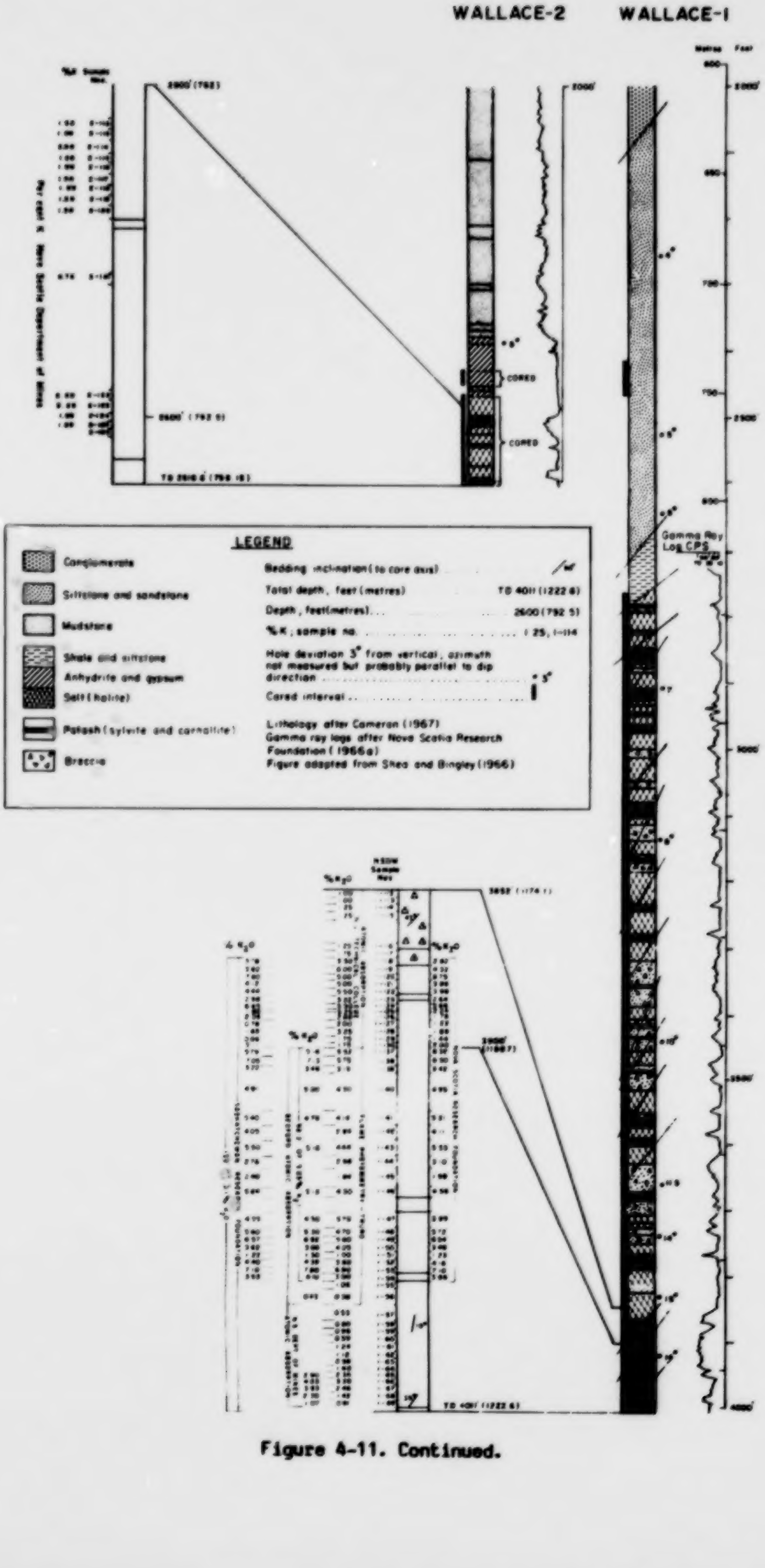
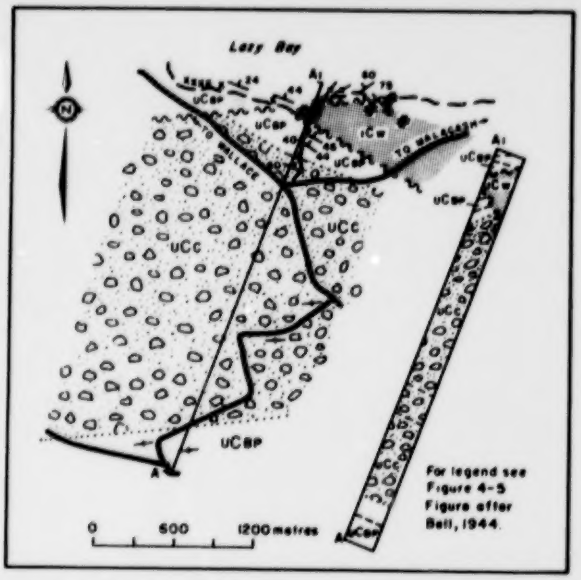

WALLACE-2
WALLACE-1
Metres
Feet
2500' (762)
2600' (792.5)
TD 2616.6' (798.6)
CORED
CORED
Per cent K. Nova Scotia Department of Mines
LEGEND
Conglomerate
Siltstone and sandstone
Mudstone
Shale and siltstone
Anhydrite and gypsum
Salt (halite)
Potash (sylvite and carnallite)
Breccia
Bedding inclination (to core axis)
Total depth, feet (metres) ... TD 4011 (1222.6)
Depth, feet (metres) ... 2600 (792.5)
%K; sample no. ... 1.25, I-114
Hole deviation 3° from vertical, azimuth not measured but probably parallel to dip direction
Cored interval
Lithology after Cameron (1967)
Gamma ray logs after Nova Scotia Research Foundation (1966a)
Figure adapted from Shea and Bingley (1966)
Gamma Ray Log CPS
%K₂O
NSDM Sample Nos.
3852' (1174.1)
3900' (1188.7)
TD 4011' (1222.6)
Nova Scotia Research Foundation
3000'
3500'
4000'

Figure 4-11. Continued.



For legend see Figure 4-5
Figure after Bell, 1944.

Figure 4-12. Geological map and cross-section, Lazy Bay.

anomaly was outlined, but geological models were not attempted.

Detailed gravity surveys were conducted on the Malagash and similar structures in Cumberland County by the Nova Scotia Research Foundation as part of the 1966 Potash Project. The survey in the Malagash-Wallace area outlined a large elongated Bouguer gravity low coincident with the Malagash-Clairmont Anticline (Fig. 4-8). A triangular outlined Bouguer gravity anomaly is evident in the Wallace Harbour area to the west. The southern (East Wallace-Lazy Bay) side of the triangle parallels the Malagash Anticline and is itself an elongate gravity low. This trend is not indicated as completely closing, but apparently opens to the north and connects with a smaller low centred in Wallace Harbour. The elongate Bouguer gravity low centred in the Malagash Mine area to the east coincides with the Windsor Group containing salt in the axis of the Anticline. Gravity model interpretations of the Wallace anomaly have been published by Bidgood and Blanchard (1967).

A total intensity magnetometer survey by the Nova Scotia Department of Mines (1966a) (Fig. 4-9) was conducted over the same area as the Nova Scotia Research Foundation gravity survey. These surveys indicate a strong correlation between magnetic high anomalies and Bouguer gravity low anomalies in the axial area of the Malagash Anticline. The magnetic anomalies are small scale, and low amplitude features concentrated along the southern flank of the gravity anomalies. A similar coincidence was described at the Roslin occurrence by the Nova Scotia Research Foundation (1967a). A study of the Roslin structure concluded the anomalies were produced by small bodies of magnetic material near the upper surface of the gravity feature. This material was speculated to be rinneite ($FeCl_2 \cdot 3KCl \cdot NaCl$).

In addition to the gravity and magnetic surveys, a reflection seismograph survey was undertaken by Beaver Geophysical Services Limited for the Nova Scotia Department of Mines and Pacific Petroleums Ltd. in 1965. Structural complications have hindered attempts to contour a structural map based on the Windsor Group (Fig. 4-17). Several major features of interest including fold axis and faults were outlined. Interpretation of the seismic data indicates a major high angle fault on the northern side of the Windsor outcrop area and a similar fault on the southern side. This evidence was used in constructing the cross-sections in Figure 4-7.

POTASH

Potash mineralized zones were first encountered in 1919 during the early stages of the development of the Malagash Salt Mine. The geology and chemistry of the potash horizons were investigated by Ellsworth (1926). He described the potash as almost pure sylvite (pink to yellowish green) occurring most commonly as disseminations and small lenses. The sylvite was associated with red coloured salt with the colouration attributed to the presence of microscopic hematite. The potash seams appear to have undergone some leaching of the soluble potassium salts because of their hygroscopic nature and extreme solubility. Chambers (1924) suggested that cracks in a zone of yellow clay filled with salt and potash minerals might indicate a period of complete drying of the depositional basin waters and sediment dessication. Leaching and small scale unconformities were also reported in banded salts associated with the potash zones. The potash was not considered to be of economic interest at that time because of low grade and uncertain continuity.

Messervey (1950) indicated that although the potash occurred mainly as small isolated lenses, three well-defined zones bearing small, persistent quantities were observed in all levels of the mine. The potash occurs over widths ranging from 10 cm to 1.5 m. On the 24th level of the mine a potash zone was proven by diamond drilling and crosscutting over a length of 300 m (1000 ft.). The reported analyses from chip sampling range from 0.51% to 11.41% KCl. Approximately 72 000 t (80 000 tons) averaging 8% KCl were proven with an additional 131 500 t (145 000 tons) of similar grade possible.

Two deep drillholes, Wallace No. 1 and No. 2, intersected steeply dipping (55°) subeconomic grade potash salts mixed with halite and mudstone. Maximum grades reported are 4.1% K_2O over 42.2 m (139 ft.) or 5.05% over 29.9 m (98.2 ft.).

Evans (1970c) described the genesis of sylvite and carnallite bearing rocks from the Wallace Nos. 1 and 2 drillholes in the Malagash structure. He indicated that although sylvite was reported to occur with halite and minor carnallite in a dense clay and mudstone breccia it was probably a secondary product from leaching of carnallite.

In a petrographic examination of the mineralized core, Evans (1970c) reported the following

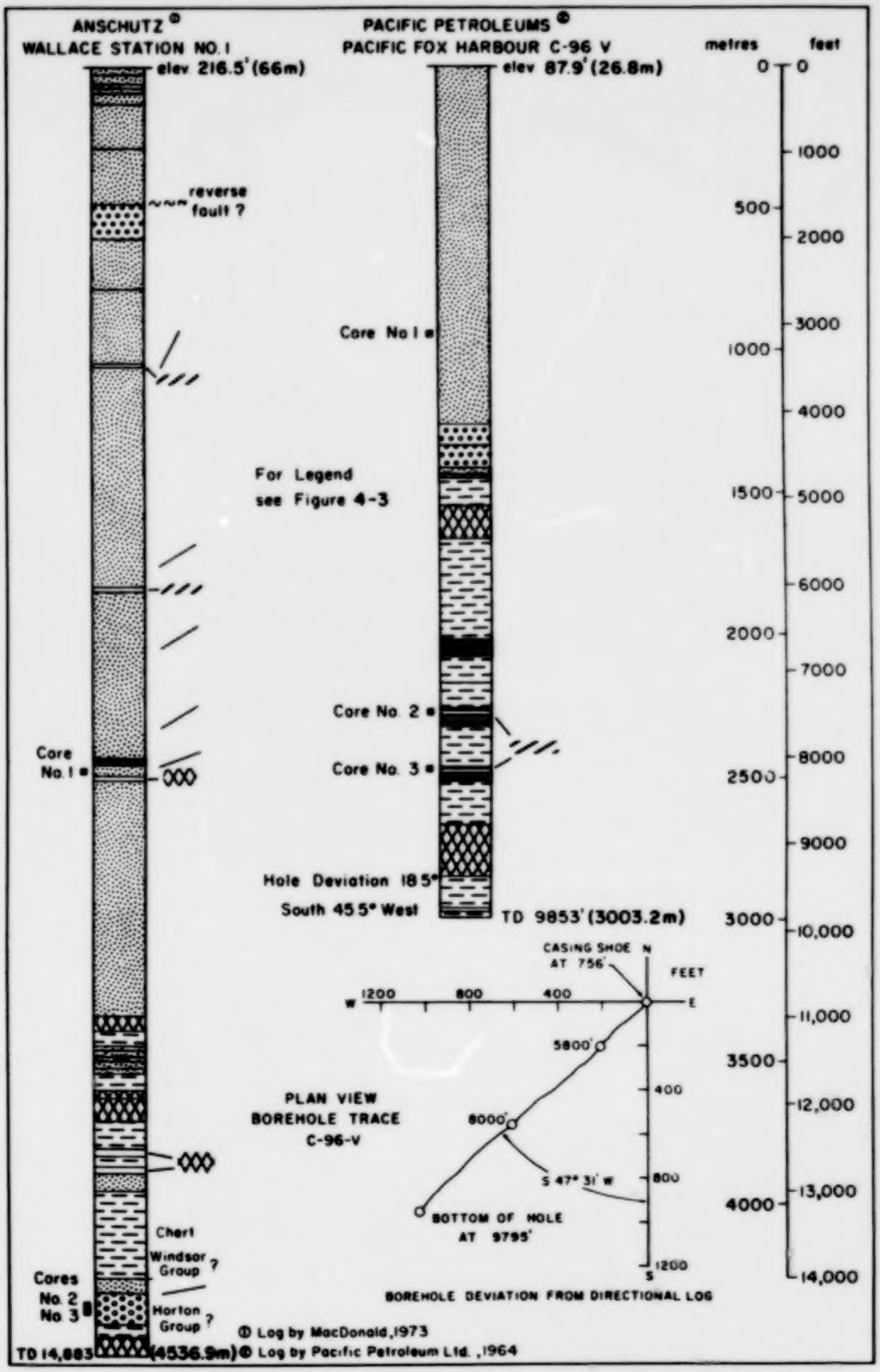
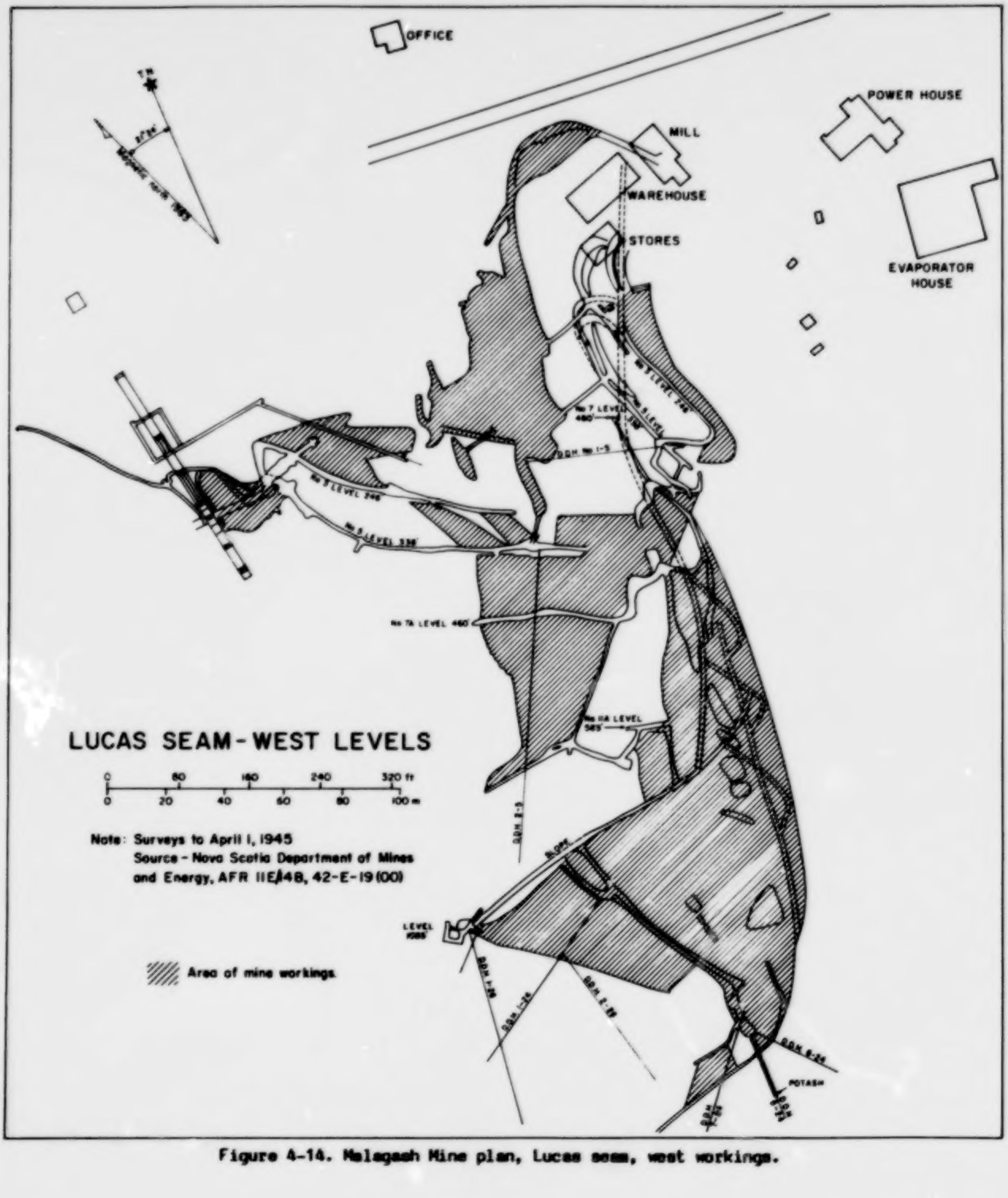
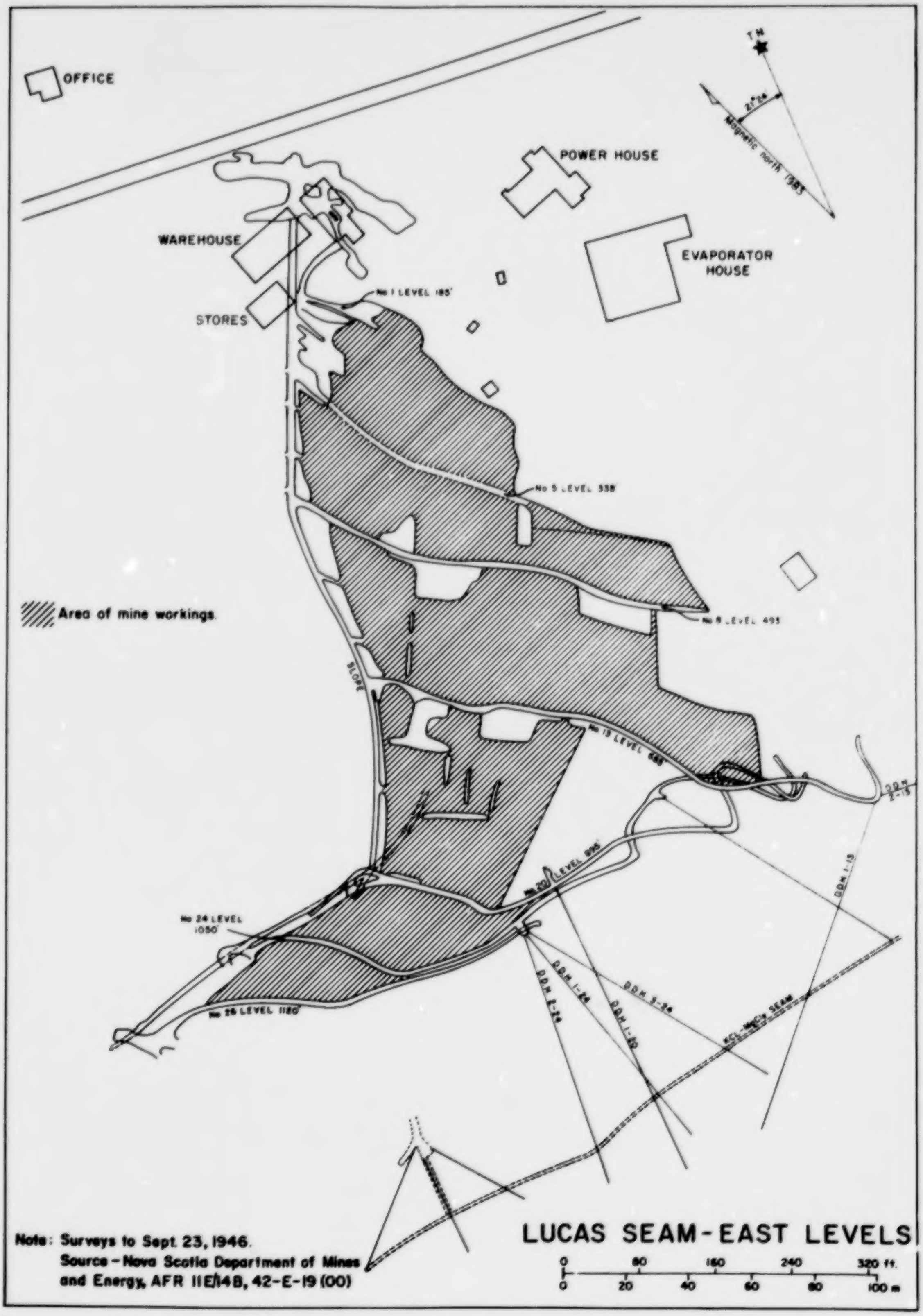

ANSCHUTZ ①
WALLACE STATION NO. 1
elev 216.5' (66m)
reverse fault ?
Core No. 1
Cores No. 2 No. 3
Chert
Windsor Group ?
Horton Group ?
TD 14,883' (4536.9m)
PACIFIC PETROLEUMS ②
PACIFIC FOX HARBOUR C-96 V
elev 87.9' (26.8m)
Core No 1
For Legend see Figure 4-3
Core No. 2
Core No. 3
Hole Deviation 18.5°
South 45.5° West
TD 9853' (3003.2m)
metres
feet
0
500
1000
1500
2000
2500
3000
3500
4000
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
CASING SHOE AT 756'
N
FEET
W
1200
800
400
E
5800'
400
8000'
800
S 47° 31' W
BOTTOM OF HOLE AT 9795'
1200
S
PLAN VIEW BOREHOLE TRACE C-96-V
BOREHOLE DEVIATION FROM DIRECTIONAL LOG
① Log by MacDonald, 1973
② Log by Pacific Petroleum Ltd., 1964

Figure 4-13. Drillhole profiles, Anschutz, Wallace Station No. 1 and Pacific Fox Harbour C-96-V, Cumberland County. (For locations see Fig. 4-5).


OFFICE
POWER HOUSE
MILL
WAREHOUSE
STORES
EVAPORATOR HOUSE
T.N.
Magnetic North 1945
LUCAS SEAM - WEST LEVELS
0
80
160
240
320 ft
0
20
40
60
80
100 m
No 7 LEVEL 460'
No 5 LEVEL 246'
No 3 LEVEL 246'
No 5 LEVEL 338'
D.D.H. No 1-5
No 7A LEVEL 460'
No 8A LEVEL 585'
D.D.H. 2-5
SLOPE
LEVEL
D.D.H. 1-26
D.D.H. 1-24
D.D.H. 2-18
D.D.H. 2-24
POTASH
Area of mine workings

Note: Surveys to April I, 1945
Source - Nova Scotia Department of Mines and Energy, AFR 11E/4B, 42-E-19(00)

Figure 4-14. Malagash Mine plan, Lucas seam, west workings.


T.N.
2°24'
Magnetic north 1985
OFFICE
POWER HOUSE
WAREHOUSE
EVAPORATOR HOUSE
STORES
No 1 LEVEL 185'
No 5 LEVEL 338'
No 8 LEVEL 495
Area of mine workings.
SLOPE
No 13 LEVEL 685'
DDH 2-15
DDH 1-15
No 20 LEVEL 895'
No 24 LEVEL 1050'
No 26 LEVEL 1120'
DDH 2-24
DDH 1-24
DDH 1-20
DDH 3-24
KCL-NaCl SEAM
LUCAS SEAM-EAST LEVELS
0
80
160
240
320 ft.
0
20
40
60
80
100 m

Note: Surveys to Sept. 23, 1946.
Source - Nova Scotia Department of Mines and Energy, AFR 11E/14B, 42-E-19 (00)

Figure 4-15. Malagash Mine plan, Lucas seam, east workings.

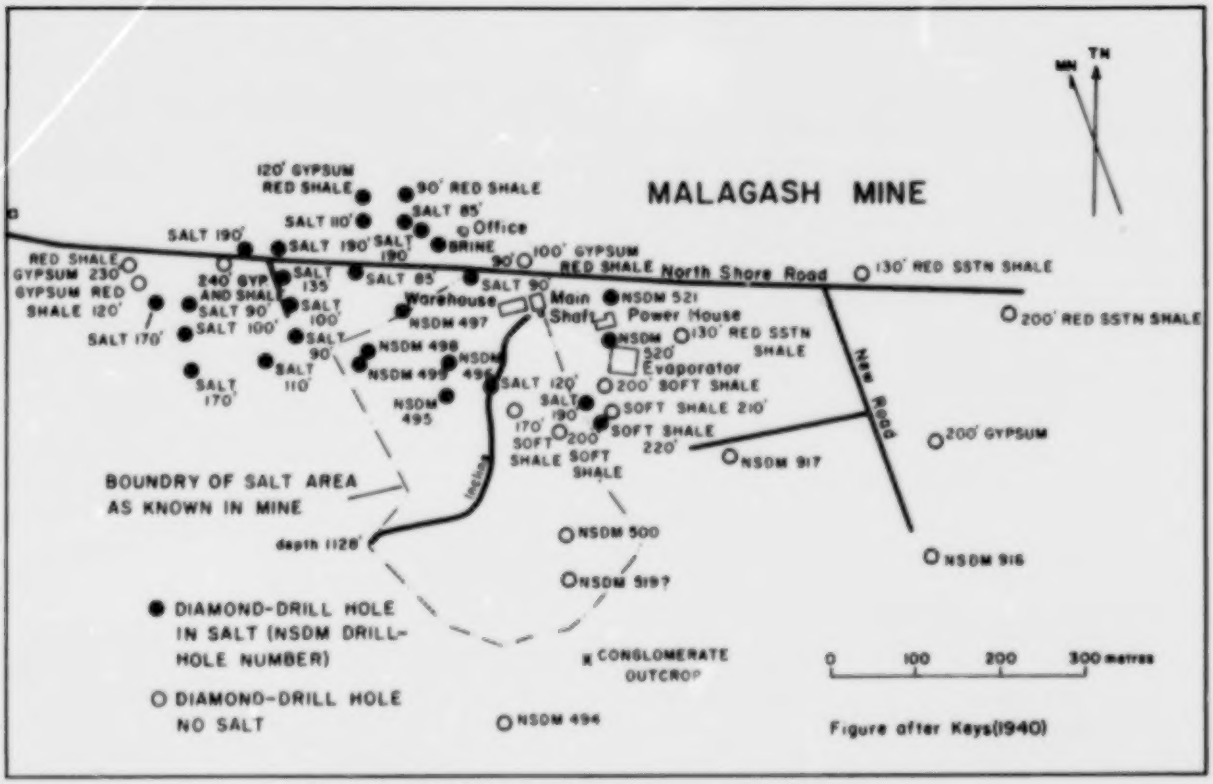

MALAGASH MINE
MN
TN
120' GYPSUM RED SHALE
90' RED SHALE
SALT 85'
SALT 110'
Office
SALT 190'
SALT 190'
SALT 190
BRINE
90'
100' GYPSUM RED SHALE
North Shore Road
130' RED SSTN SHALE
RED SHALE GYPSUM 230
GYPSUM RED SHALE 120'
240' GYP. AND SHALE
SALT 135
SALT 85
SALT 90
Warehouse
Main Shaft
NSDM 521
Power House
200' RED SSTN SHALE
SALT 170'
SALT 90'
SALT 100'
SALT 100'
SALT 90'
NSDM 497
NSDM 498
NSDM 499
NSDM 496
NSDM 520
130' RED SSTN SHALE
Evaporator
New Road
SALT 170'
SALT 110'
NSDM 495
SALT 120'
SALT 190
200' SOFT SHALE
SOFT SHALE 210'
170' SOFT SHALE
200 SOFT SHALE
SOFT SHALE 220'
NSDM 917
200' GYPSUM
BOUNDRY OF SALT AREA AS KNOWN IN MINE
Incline
depth 1128'
NSDM 500
NSDM 519?
NSDM 916
● DIAMOND-DRILL HOLE IN SALT (NSDM DRILL-HOLE NUMBER)
○ DIAMOND-DRILL HOLE NO SALT
CONGLOMERATE OUTCROP
0 100 200 300 metres
NSDM 494
Figure after Keys(1940)

Figure 4-16. Drillhole location map, Malagash Mine.

paragenetic sequence: sylvite after carnallite, halite pseudomorphs after carnallite, and halite after sylvite after carnallite. Byproducts of the latter reaction include hematite, quartz and talc. The talc occurs as reaction rims and the hematite and quartz as hexagonal flakes and euhedra. Evans (1970c) concluded that the original sediment was a carnallite and halite rich clay which, through deformation was associated with salt intrusion, metamorphosed into the present assemblage.

GEOCHEMISTRY

A sample of water taken from a "waterspring at peak of active salt dome South Wallace" by Cameron (1965a) had the following analyses compared with analyses of the brine from Peter Murphy's well reported by Cole (1930a) (Table 4-1). The salt spring sampled by Cameron is dilute and has a high content of $CaSO_4$ indicating a probable gypsum and halite source. The salt brine analyzed by Cole (1930a), in contrast, is relatively strong and low in $CaSO_4$.

A substantial number of chemical analyses have been performed and reported by workers including Ellsworth (1926), Cole (1930a), Chambers (1924) and Hayes (1920). The most detailed study was that by Ellsworth (1926) who compiled much of the previous data and investigated in some detail the chemistry of the potash zones as exposed in the Malagash Mine. Table 4-2 (Appendix 2) contains analyses of salt samples collected from the Malagash Mine and compiled by Ellsworth (1926).

Table 4-3 (Appendix 2) contains the results of potash analyses made by Ellsworth (1926) on samples collected in 1919 during early mine development. Series A, B, C and E were sampled from a 5 cm (2-inch) channel cut normal to the dip, with each successive number representing a 30 cm (1-foot) interval of the channel from top to base. Sample A-1 was reported by Ellsworth (1926) to represent the uppermost part of the "red zone" and C-6 the lowest part accessible at that time. Series D consists of samples obtained from drilling the same interval as the B series. Series E is supposedly the same interval as series A only taken on the opposite side of the drift. In addition more detailed determinations were made by Ellsworth (1926), on composite samples of the A, B, C and D sections and the results are presented in Table 4-4 (Appendix 2). Tabulations of chemical analyses of core samples from the 1966 Potash Project drill program are also presented in Appendix 2.

ECONOMIC CONSIDERATIONS

The Malagash deposit consists mainly of halite with thin, but significant zones of low grade

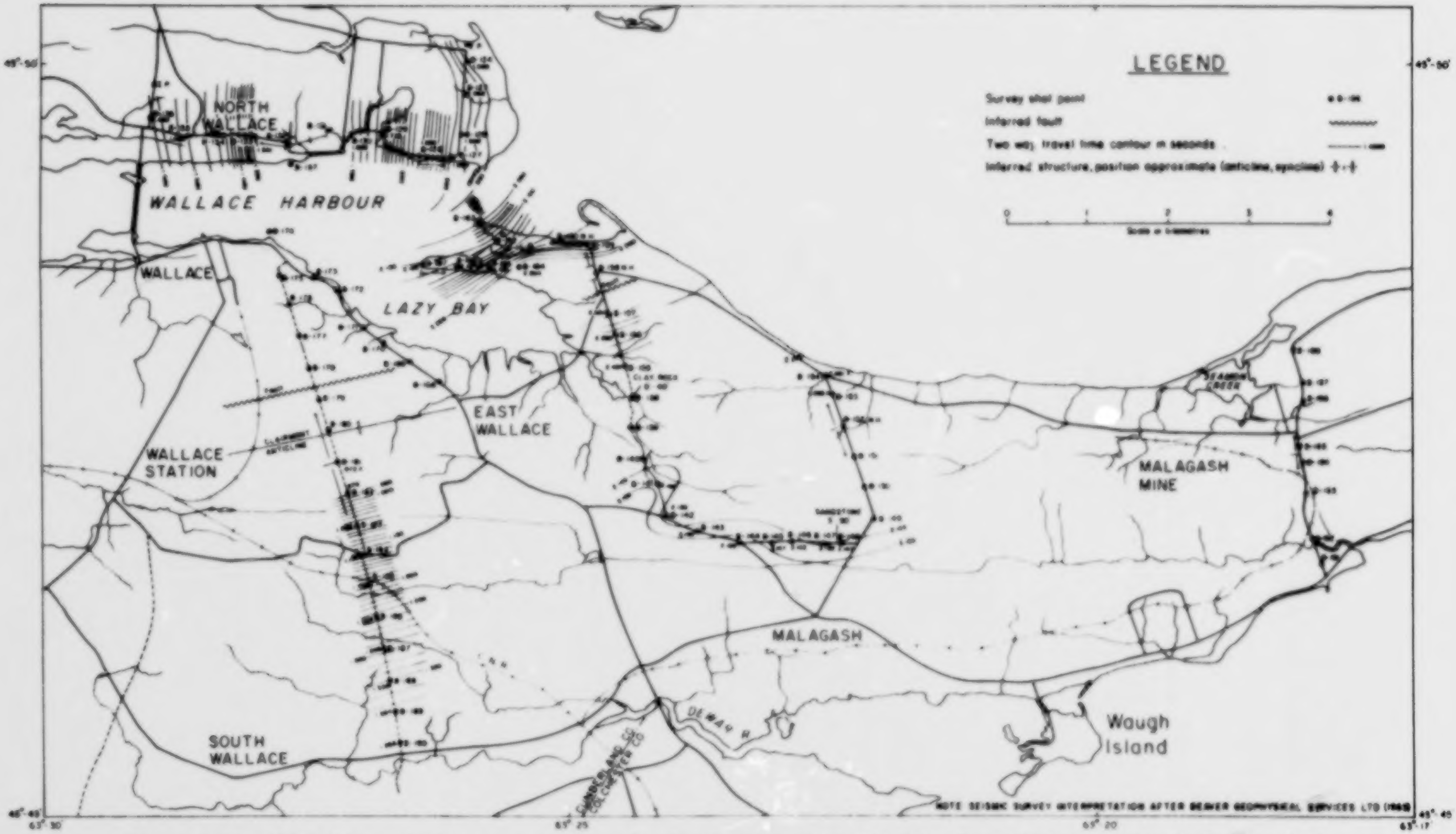

LEGEND
Survey shot point
Inferred fault
Two way travel time contour in seconds
Inferred structure, position approximate (anticline, syncline)
0 1 2 3 4
Scale in kilometres
NORTH WALLACE
WALLACE HARBOUR
WALLACE
LAZY BAY
EAST WALLACE
WALLACE STATION
SOUTH WALLACE
MALAGASH
MALAGASH MINE
Waugh Island
DEWAR R.
CUMBERLAND CO.
COLCHESTER CO.
45°50'
45°45'
63°30'
63°25'
63°20'
63°17'
NOTE SEISMIC SURVEY INTERPRETATION AFTER

Figure 4-17. Reflection seismic survey showing structural contours on a Windsor Group horizon, Malagash-Wallace area.

Table 4-1. Analyses of salt brines, South Wallace and Malagash.

	South Wallace Cameron (1965a) (parts per million)	**Peter Murray well, Malagash Cole (1930a) (milligrams per litre)**
Sodium	500+	99 500
Potassium	20.0	550
Iron	n.d.	70
Calcium	810.0	1 370
Manganese	63.2	220
SO_4	n.d.	3 110
Chloride	250+	Chlorine 154 700
Ph	7.3	n.d.
Conductance (mhos x 10-5)	1800	n.d.
Sg	n.d.	1.200 (15.5°C)

Hypothetical Combination
(parts per thousand)

$NaCl$	252.90
KCl	1.04
$MgCl_2$	0.86
$CaCl_2$	0.22
$CaSO_4$	4.42
Fe_2O_3	0.10

potash minerals associated with brecciated mudstone. Part of the deposit was mined for salt in the Malagash Salt Mine which operated on the eastern end of the deposit between 1919 and 1959. Potash, mainly sylvite, was encountered in several variable, but continuous low grade zones as well as in scattered lenses in the mine. Potash was intersected in the Wallace No. 1 drillhole 10 km to the west of the mine and in Wallace No. 2 drillhole 4.25 km west of the mine on the same structure. Much of the deep exploratory drilling was concentrated on the southern limb of the steeply dipping structure.

The area is readily accessible by paved highways, gravel roads and railway lines. The Northumberland Strait shore and Wallace Harbour are within easy reach of most of the area and could potentially be developed for tide water shipping facilities. The deposit is not being used at present and the area will require further exploration to determine if economic salt and potash deposits are present.

NAPPAN DEPOSIT

LOCATION

The Nappan deposit is located in the vicinity of Nappan 5 km south of Amherst (NTS 21H/16), northwestern Cumberland County, northern Nova Scotia (Figs. 1-4, 1-10 and 4-18).

The area is readily accessible by paved highway from the Trans-Canada Highway 104 that runs between Truro through Amherst to New Brunswick. The mainline of the Canadian National Railway between Truro and Montreal passes within 1.5 km of the Sifto Salt Company brining mine. The area is located approximately 8 km south of the Cumberland Basin where potential tidal power installations are being evaluated.

The area is located near the lowlands of the Chignecto Isthmus which lie between Nova Scotia and New Brunswick. These marshy lowlands rarely exceed 30 m in elevation and are generally at or near sea level. The highland area to the south is characterized by undulating hills with elevations of up to 150 m.

HISTORICAL BACKGROUND

The Nappan deposit is located in the Minudie Anticline that was explored for potential petroleum deposits by Imperial Oil Limited between 1926 and 1932 and by Sun Oil Company Limited between 1945 and 1947.

The Minudie structure has been known in geological literature for over 100 years. Logan (1845) described and measured in detail the strata of the coastal section from the crest of the Minudie Anticline to the middle of the adjoining Cumberland coal basin syncline. He reported a section, in excess of 1500 m thick, of conformable Pennsylvanian sediments containing an upright standing coal forest. Dawson (1868) elaborated on the paleontology of the section.

A reconnaissance survey of Nova Scotia in 1926 by International Petroleum Company (Imperial Oil Limited) outlined the Minudie structure as having good petroleum potential which warranted further investigation (Roliff, 1932).

Pohl in Hayes (1931) reported that salt water was encountered in a water well near Upper Nappan. Fresh water used in the 1927 drilling operation returned salty between 70 and 85 m (230 and 280 ft.). This indicated that at least part of the structure contained salt although its precise configuration was unknown.

In 1928 Imperial Oil drilled six test holes near Nappan, south of Amherst, to confirm the nature of the anticlinal structure. Four additional holes were drilled in 1929. Early in 1931 a wildcat test well, Amherst No. 1, was drilled to a total depth of 1260 m (4134 ft.). The hole was stopped in the Windsor Group gypsum, anhydrite and salt without completely penetrating the sequence, establishing that the structure was not just a simple anticline, but rather has a dome or diapiric configuration with accompanying thickening of the core evaporites.

In late 1942 the Nova Scotia Department of Mines studied the Nappan area in connection with a proposed drilling program to check the possible extension of the salt beds encountered in the Imperial Oil Amherst No. 1 hole. The test area was located approximately 1.5 km west-southwest of the Imperial Oil hole. Although the first hole was abandoned, the second and third holes intersected salt. Based on the success of the Nova Scotia Department of Mines investigation and the Imperial Oil Amherst No. 1 well, Maritime Industries Ltd. began boring brine wells for the production of evaporated salt at Nappan in late 1945. In the same year Sun Oil Company spudded Sunoco No. 1 exploratory well for petroleum. The Sunoco well intersected salt but had to be abandoned at 1981 m (6499 ft.) due to drilling problems. In 1946 this well was relocated 46 m north and redrilled as Sunoco No. 1A. It reached Horton Group strata at approximately 1850 m and was finally abandoned at a depth of 3506 m in 1947. The section reported as Horton is now known to belong to the Canso-Riversdale Group based on spores (Howie, personal communication, 1982). By 1947 the Maritime Industries Nappan operation was in production. The company took over the abandoned Sunoco Nos. 1 and 1A oil wells and used these for brine production. The Nappan operation is still in production and is now owned by Domtar Chemical Ltd. Sifto Salt Division.

In 1975 Gulf Oil Canada Limited et al. drilled Hastings No. 1 in exploration for petroleum near Hastings, approximately 9 km east of Amherst. This well which intersected Upper Carboniferous strata was reported to have been abandoned in "Older Paleozoic" metamorphic rocks that were first encountered at 2783 m (9130 ft.). Rocks of the Windsor Group were not identified in this borehole.

GEOLOGY

The geology in the Nappan area was described and mapped by geologists with Imperial Oil Ltd. A simplified version of this map is presented in Figure 4-18. In general form the structure at Nappan is that of an eroded east-west trending anticline (Fig. 4-18). This anticlinal structure, known as the Minudie Anticline or Anticlinorium, extends from Shepody Bay in New Brunswick on the west, to near Brookdale, approximately 3 km southeast of Amherst, on the east. Geologically the Minudie Anticlinorium is defined by Lower and Upper Carboniferous units with the oldest, Windsor Group occurring in the axial region and the successively younger Middleborough Formation, Boss Point Formation, and Pictou Group rocks on the flanks.

The Windsor Group consisting of red shale, gypsum, and anhydrite rocks in the core area, was assigned by previous workers such as Roliff (1932) to the A Subzone. These rocks, where exposed, are reported to be highly folded and contorted. They exhibit flow structures and form a series of small and large complex antiforms and synforms within the larger Minudie Anticlinorium. The northern and southern limbs of the Anticlinorium are characterized by relatively consistent strikes and moderate dips, in contrast to the more variable attitudes in the core region. On the northern flank of the Anticlinorium, Roliff (1932) reported red shales of the Windsor Group Subzone A overlying the gypsum, but the overlying Subzone B limestone succession is apparently concealed by the overlapping Pictou Group. In many areas the Windsor Group is overlain by chocolate red shale and siltstone of the Transition Formation of Roliff (1932) which appears to be equivalent to the Maringouin or Shepody Formation of Shaw (1951) or the Middleborough Formation of Bell (1944). The Middleborough Formation is overlain by a sequence of sandstone and shale called the Boss Point Formation (Riversdale Group).

The Boss Point Formation is in turn overlain with apparent angular unconformity by sandstone, shale, and conglomerate of the Pictou Group. On the northern flank of the structure in the Maringouin Peninsula, New Brunswick, gently dipping Pictou Group rocks rest upon highly inclined beds of the Boss Point Formation (Roliff, 1932).

The stratigraphy of the Windsor Group outcrops in the area were described by Bell (1944, 1958). The lower evaporite succession (A Subzone) of the Windsor Group is overlain with uncertain relationship by red shales and fossiliferous B Subzone limestone. The limestones are exposed at several localities around the Minudie Anticlinorium in particular on its southern limb. Hayes (1931) described the section at Lower Maccan on the southern limb of the structure as having 18.3 m (60 ft.) of red and grey shale overlain by a 27 m (90 ft.) bed of limestone similar to that at Lime-kiln Brook (Fig. 4-19). The strike exposure of the limestone yields good collecting of the fauna that he indicated is dominated by abundant Diodoceras avonensis, the B Subzone guide fossil. Sinkhole topography reported to stratigraphically overlie the limestone by approximately 76 m (250 ft.) was interpreted as a gypsum horizon. According to Hayes (1931) the gypsum occurred as a lens, because gypsum was known only to occur stratigraphically below the Subzone B limestones. The sinkhole topography may, however, be related limestone karst. Hayes (1931) reported that 366 m (stratigraphic) (1200 ft.) of fine grained ripple marked sandstone (Middleborough Formation?) are reported to overlie the B Subzone limestone section.

Bell (1958) studied the Maccan River section in more detail and interpreted the succession somewhat differently. His section has a total exposed thickness of 88 m (290 ft.). He recognized a two part subdivision instead of a single limestone unit in which a limestone of the

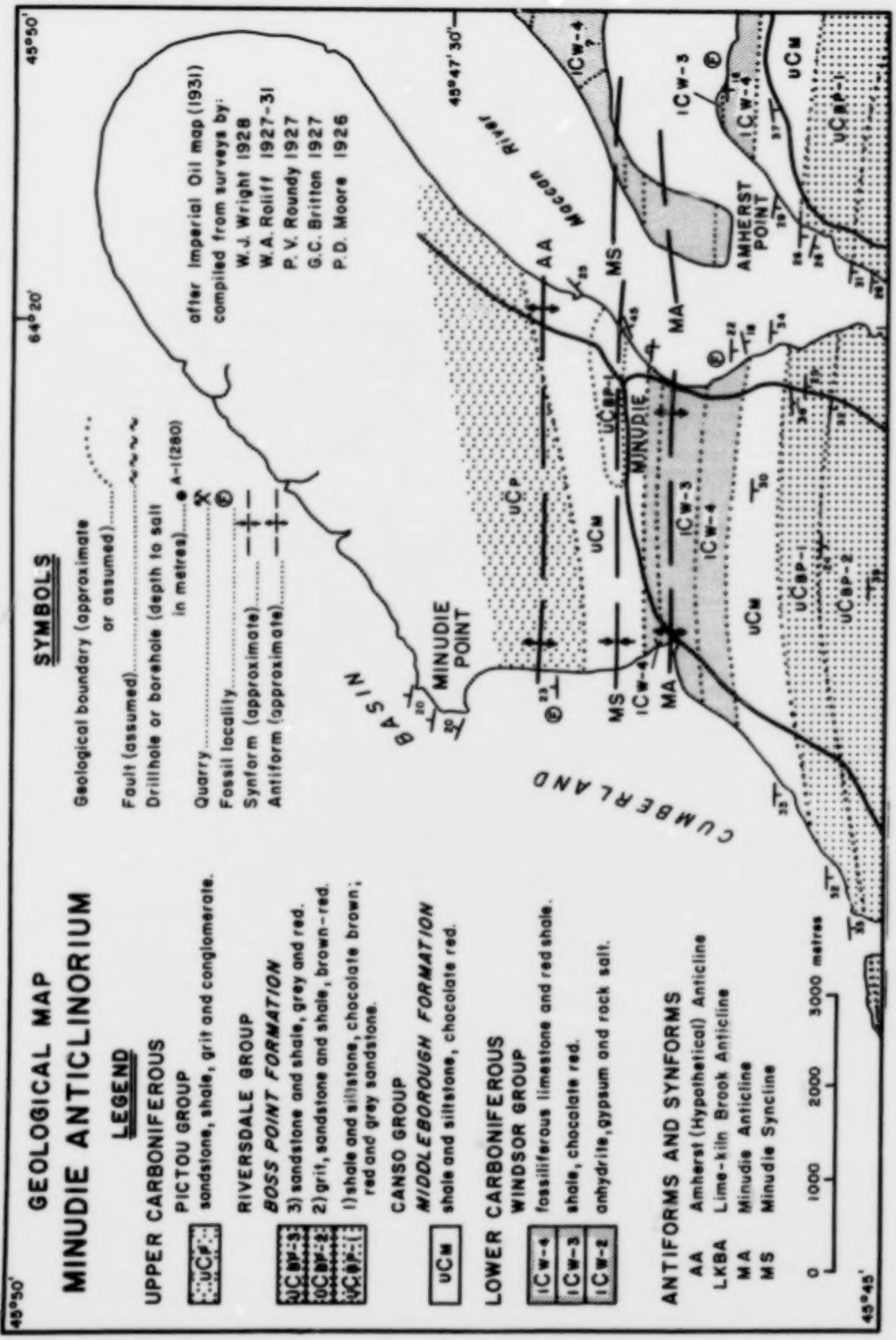

GEOLOGICAL MAP
MINUDIE ANTICLINORIUM
LEGEND
UPPER CARBONIFEROUS
PICTOU GROUP
uCP sandstone, shale, grit and conglomerate.
RIVERSDALE GROUP
BOSS POINT FORMATION
uCBP-3 3) sandstone and shale, grey and red.
uCBP-2 2) grit, sandstone and shale, brown-red.
uCBP-1 1) shale and siltstone, chocolate brown; red and grey sandstone.
CANSO GROUP
MIDDLEBOROUGH FORMATION
uCM shale and siltstone, chocolate red.
LOWER CARBONIFEROUS
WINDSOR GROUP
lCW-4 fossiliferous limestone and red shale.
lCW-3 shale, chocolate red.
lCW-2 anhydrite, gypsum and rock salt.
ANTIFORMS AND SYNFORMS
AA Amherst (Hypothetical) Anticline
LKBA Lime-kiln Brook Anticline
MA Minudie Anticline
MS Minudie Syncline
0 1000 2000 3000 metres
SYMBOLS
Geological boundary (approximate or assumed)
Fault (assumed)
Drillhole or borehole (depth to salt in metres)
A-1(280)
Quarry
Fossil locality
Synform (approximate)
Antiform (approximate)
after Imperial Oil map (1931)
compiled from surveys by:
W. J. Wright 1928
W. A. Roliff 1927-31
P. V. Roundy 1927
G.C. Britton 1927
P.D. Moore 1926
45°50'
64°20'
45°47' 30"
45°45'
CUMBERLAND
BASIN
MINUDIE POINT
MINUDIE
AMHERST POINT
MACCAN RIVER
AA
MS
MA
uCP
uCM
uCBP-1
uCBP-2
lCW-3
lCW-4

Figure 4-18. Geology in the vicinity of the Nappan deposit, Minudie Anticline.

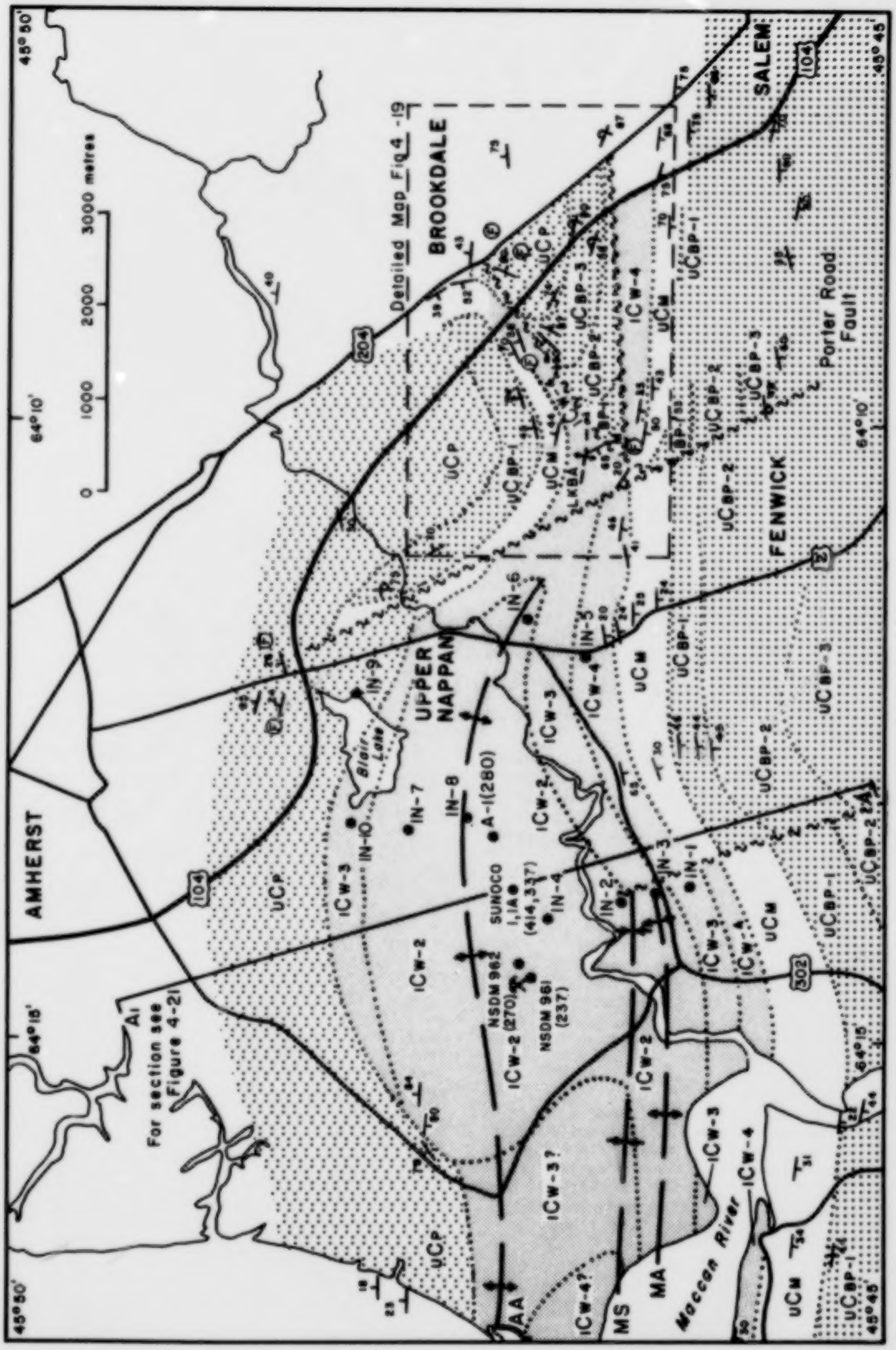

AMHERST
UPPER NAPPAN
BROOKDALE
FENWICK
SALEM
Porter Road Fault
Maccan River
Blair Lake
Detailed Map Fig 4-19
For section see Figure 4-21
A
A'
0 1000 2000 3000 metres
45°50'
45°45'
64°10'
64°15'
104
204
302
2
uCP
uCM
uCBP-1
uCBP-2
uCBP-3
lCw-2
lCw-3
lCw-4
lCw-3?
lCw-4?
LKBA
AA
MS
MA
IN-1
IN-2
IN-3
IN-4
IN-5
IN-6
IN-7
IN-8
IN-9
IN-10
A-1(280)
SUNOCO 1,1A (414,337)
NSDM 962 (270)
NSDM 961 (237)

Figure 4-18. Continued.

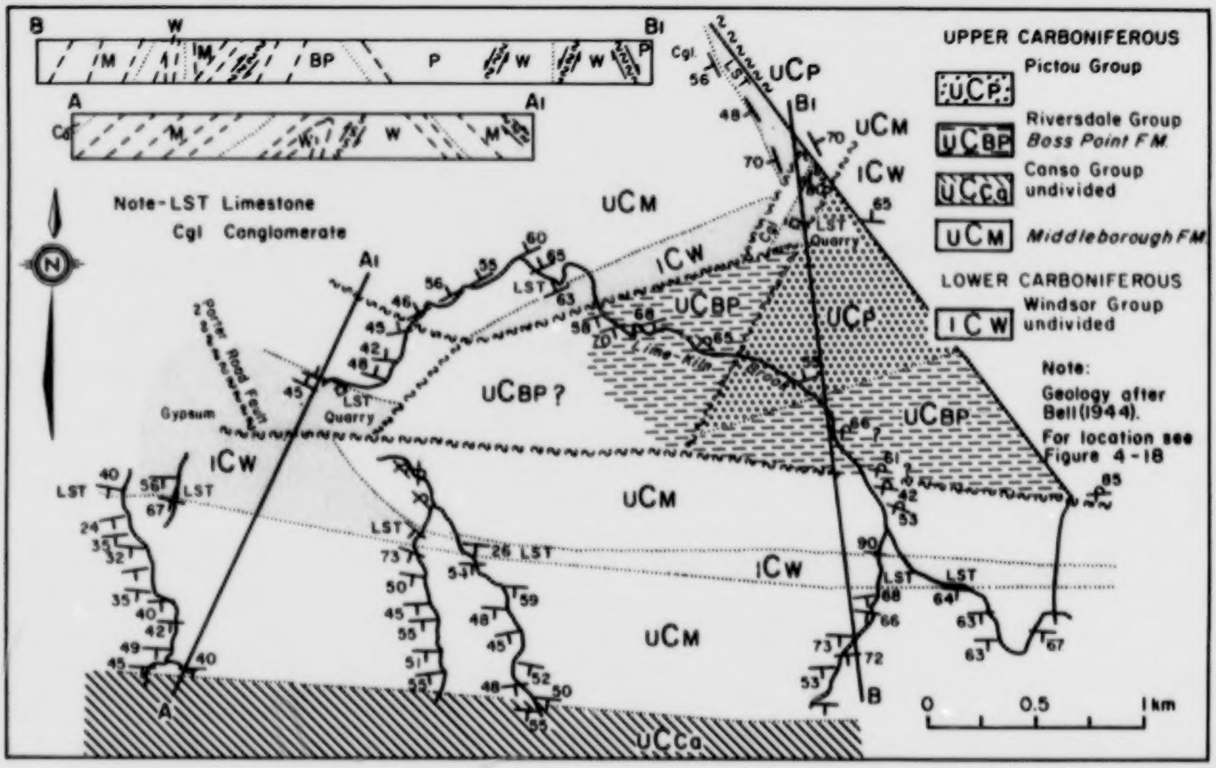

B
W
B1
M
A1
M
BP
P
W
W
P
A
A1
Cgl
M
W
W
M
Note-LST Limestone
Cgl Conglomerate
N
UPPER CARBONIFEROUS
uCP Pictou Group
uCBP Riversdale Group Boss Point F.M.
uCCa Canso Group undivided
uCM Middleborough F.M.
LOWER CARBONIFEROUS
lCW Windsor Group undivided
Note:
Geology after Bell (1944).
For location see Figure 4-18
uCP
uCM
lCW
uCM
lCW
uCBP
uCP
uCBP?
uCBP
lCW
uCM
lCW
uCM
uCCa
LST Quarry
LST Quarry
Porter Road Fault
Lime-Kiln Brook
Gypsum
LST
0
0.5
1 km

Figure 4-19. Lime-kiln Brook area, geological map and cross-section.

B Subzone (units 13, 14) is overlain by a thicker C Subzone limestone (units 17-26). Unfortunately, the fossils he reported from the C limestone are not specifically diagnostic to this Subzone. Moore and Ryan (1976) indicated a longer range for these forms.

The Minudie structure narrows drastically from the Maccan area westward (Fig. 4-18). B Subzone limestone strata mapped by Roliff (1932) in the Minudie area on the northern limb of the structure are indicated as being overturned and dipping southward (Fig. 4-18). Bell (1958) described this section, located south of the Minudie wharf, as consisting of at least four Windsor Group limestone beds separated by red siltstone, having a total section thickness of greater than 44.3 m (145.5 ft.).

Roliff (1932) postulated the Minudie Anticlinorium consisted of two major internal folds. These folds are, from south to north, the Minudie Anticline, Minudie Syncline and Hypothetical (Amherst) Anticline, in which the northern limbs are generally steeper than the southern limbs (Fig. 4-18). The dips of these fold limbs vary at different locations along the strike of the major Minudie structure, being nearly vertical near Maringouin Peninsula and approximately 22° in the southern limb at Minudie. The northern limb at Minudie is overturned. In the Nappan Station and Upper Nappan area, the southern dips are moderate and the Minudie and Amherst Anticlines begin to merge. Here they are separated by a tightly folded syncline. At this location the inferred northward dips are concealed and Roliff (1932) reported that shallow drilling indicated dips of about 45°.

Numerous minor faults transverse to the structural strike are reported along the length of the folds. The only fault of major displacement Roliff (1932) reported is the Porter Road Fault (Figs. 4-18, 4-19). It is important because it forms part of the eastern closure of the structure. Bell (1944) described the Porter Road Fault as a transverse upthrust (reverse fault), but limited its southerly extent by terminating it against an east-west (longitudinal) trending thrust fault (Fig. 4-19). The geological situation in the eastern end of the Minudie Anticlinorium is more complex than that described in the western area (Fig. 4-19). Bell (1944) reported that the Middleborough Formation lies conformably upon a "limestone zone" of the Windsor Group. This sequence is exposed in the Lime-kiln Brook quarry area. The Middleborough Formation comprising brick-red sandstone, siltstone, and shale, is indicated to have a total thickness of 480 m (1575 ft.). The Middleborough Formation was reported by Bell (1944) to be overlain conformably, in the Fenwick area, by

Canso Group comprising grey and red sandstone and red shale.

The Lime-kiln Brook section was described by Bell (1944, 1958). It is noteworthy that Bell (1958) reconsidered his earlier assessment and indicated that the Windsor Group-Middleborough Formation contact might be a disconformable rather than conformable contact.

The fauna of bed 3 of the Lime-kiln Brook section indicates an upper part of Subzone B of the Windsor Group. The presence of *Nodosinella priscilla* (in bed 18) probably indicates Subzone C (Bell, 1944).

Upstream in Lime-kiln Brook approximately 1 km east-northeast from the quarry, the uppermost limestone unit from the "quarry section" is exposed. In this exposure, Bell (1944) reported that the limestone section was overlain by Middleborough Formation arkosic grit. The same limestone unit is again exposed farther east near Brookdale, where it was reportedly quarried for manganese. Here again Bell (1944) reported that it is overlain by red grit and conglomerate at the base of the Middleborough Formation. The limestone was considered by Bell (1944) to be probably C Subzone. The upper units of this limestone section he equated with the upper units in the Maccan River section to the west. The Lime-kiln Brook area is extensively faulted according to Bell's (1944) map (Fig. 4-19). He indicated that the southern limb of the Minudie Anticline was folded back upon itself. The upper beds of the limestone section and conglomerate at the base of the Middleborough, he reported to be poorly exposed in the axial area of the subordinate fold. This fold apparently accompanies an east-west trending thrust fault where Middleborough Formation strata are thrust against the Boss Point Formation. The Boss Point Formation and the sometimes unconformably overlying Pictou Group strata are down faulted against the Windsor Group limestone section or against Middleborough Formation strata on the northern limb of the Minudie Anticlinorium.

Lower Windsor A Subzone gypsum outcrops in the central region of the Minudie Anticlinorium, and was quarried to a small extent, near Nappan. Bell (1944) stated that the Windsor limestone section (B and C Subzones) is underlain by a section of brownish to brick red mudstone, sandstone, shale, and then gypsum. He further indicated that if the lowest Windsor limestone outcropping in the brook west of Lime-kiln Brook is continuous in section with the gypsum intersected in the Imperial Oil drillhole located approximately 425 m to the north, then the interval comprising red siltstone and shale is in the order of 245 m. Hayes (1931), using similar reasoning, indicated this interval to be approximately 275 m thick.

Deep exploration drilling has provided a better understanding of the geology of the Minudie Anticlinorium. The early uncomplicated anticlinal model was proven to be invalid when more than 1000 m of evaporites were intersected. Deep drilling for petroleum in the Nappan area was under taken in three holes: the first, Amherst No. 1 was drilled by Imperial Oil Limited in 1931, and two were drilled by Sun Oil Company, Sunoco No. 1 and No. 1A between 1945-1947 (Fig. 4-20).

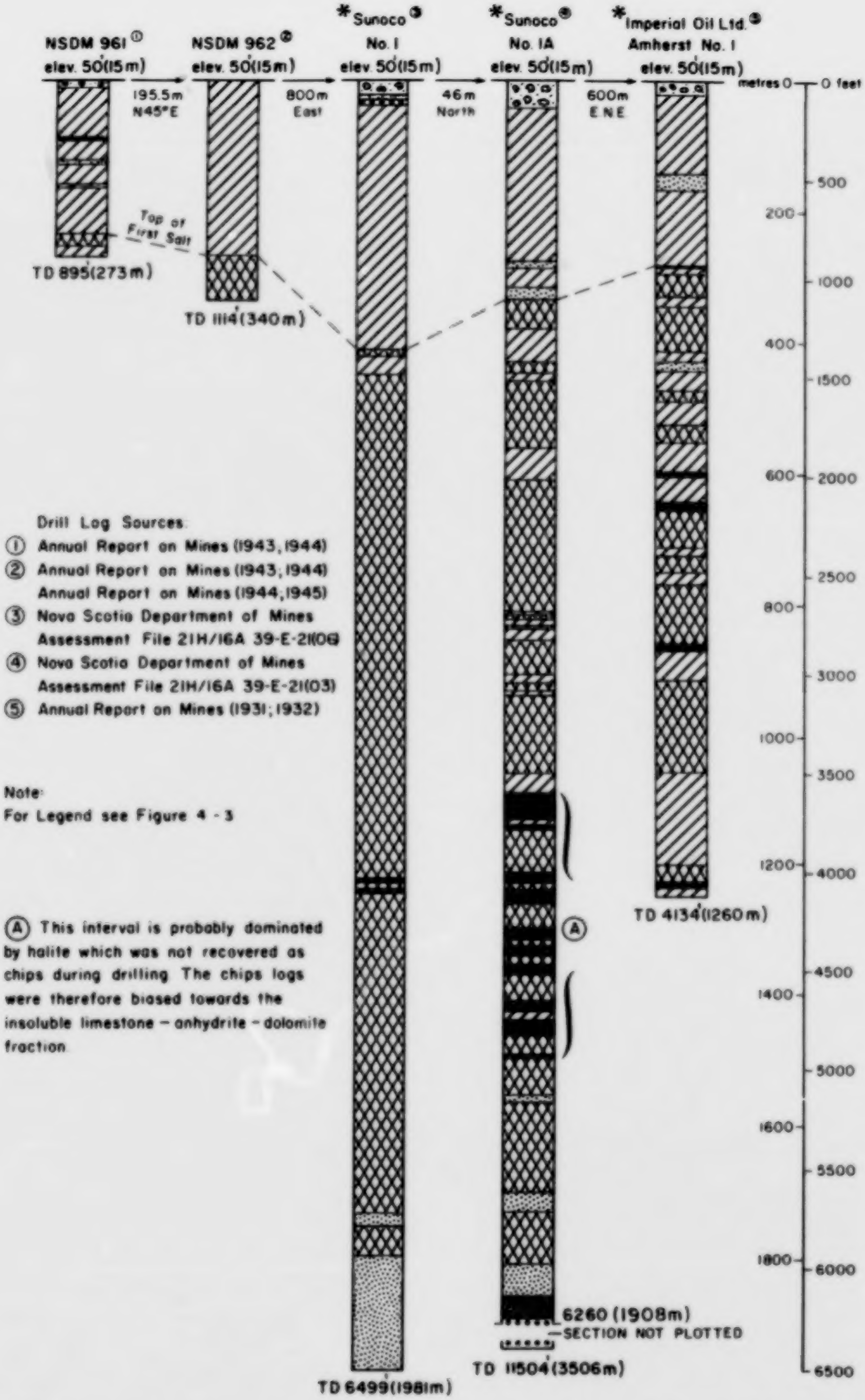
Prior to the drilling of the Amherst No. 1 well, Imperial Oil Ltd. drilled ten shallow holes with depths ranging between 32 and 243 m to evaluate the configuration of the structure (Fig. 4-18). Gypsum was penetrated as bedrock in six of these. The four remaining holes penetrated younger strata flanking the structure. Roliff (1932) reported that in planning the Amherst No. 1 test, it was estimated that the Windsor Group gypsum, salt and limestone would not extend beyond the depth of 300 m. It was estimated that a sequence of 600 to 1200 m of red and chocolate shales and conglomerate would be found, followed by the Horton Group Albert Formation.

Amherst No. 1 first penetrated salt at 280.4 m after intersecting an interbedded (collapse brecciated) sequence of gypsum, sandstone, conglomerate, limestone, and dolostone. Between 280.4 and 488 m, seven salt intervals were intersected with an aggregate thickness of 52 m. From 488 m to the total depth at 1260 m, 8 salt beds totalling 384 m were intersected with major thick gypsum and anhydrite interbeds. The major salt intervals intersected are: 527.3-554.7 m, 664.5-716.3 m, 734.6-759 m, 777.2-868.7 m, 923.5-1063.8 m (981.5-986.5 m is reported to be similar in appearance to the Malagash potash mineralized zone), and 1207-1237.5 m. The salt is described from drill cuttings as being mostly white to clear white with some pink and reddish coloured salt locally abundant.

The stratigraphic and structural configuration of the salt units encountered in the drilling was not precisely known. Cross-sections drawn by Imperial Oil Limited to accompany their geological map portray the evaporite succession in the core area of the Minudie Anticlinorium as being tightly folded and probably highly contorted. This severe deformation appears to be due to the mobile nature of the evaporites produced by their flowage and has resulted in a great thickening in this part of the section (Fig. 4-21). This situation is not unlike that encountered in the Pugwash and Malagash Mines and probably occurs in all the Windsor Group outcrop areas in the Cumberland area.

In early 1943 the Nova Scotia Department of Mines began diamond drilling approximately 1500 m west-southwest of the Amherst No. 1, in the vicinity of an old gypsum quarry. Salt was penetrated at 237.4 m (779 ft.) in NSDM 961 and was abandoned in salt at 273 m (895 ft.). NSDM 962, drilled 194 m northeast, penetrated salt at 270.7 m (888 ft.) and was abandoned at 340 m (1114.5 ft.). The depth to salt in both drillholes is similar to the 280 m (920 ft.) depth to salt in the Amherst No. 1 well. Maritime Industries Limited began boring brining wells for the production of evaporated salt in 1945.

In 1945 Sun Oil Company drilled Sunoco No. 1 (Fig. 4-20) in search of petroleum approximately 800 m east of the NSDM 962 and 600 m west-southwest of Amherst No. 1. Salt was first pene-


NSDM 961 ①
elev. 50'(15m)
195.5m N45°E
NSDM 962 ②
elev. 50'(15m)
800m East
*Sunoco ③
No. 1
elev. 50'(15m)
46m North
*Sunoco ④
No. 1A
elev. 50'(15m)
600m ENE
*Imperial Oil Ltd. ⑤
Amherst No. 1
elev. 50'(15m)
metres 0
0 feet
500
200
1000
400
1500
600
2000
2500
800
3000
1000
3500
1200
4000
4500
1400
5000
1600
5500
1800
6000
6500
Top of First Salt
TD 895'(273m)
TD 1114'(340m)
TD 4134'(1260m)
Ⓐ
6260 (1908m)
SECTION NOT PLOTTED
TD 11504'(3506m)
TD 6499'(1981m)

Drill Log Sources:
① Annual Report on Mines (1943, 1944)
② Annual Report on Mines (1943; 1944)
Annual Report on Mines (1944, 1945)
③ Nova Scotia Department of Mines Assessment File 21H/16A 39-E-21(06)
④ Nova Scotia Department of Mines Assessment File 21H/16A 39-E-21(03)
⑤ Annual Report on Mines (1931; 1932)

Note:
For Legend see Figure 4 - 3

Ⓐ This interval is probably dominated by halite which was not recovered as chips during drilling. The chips logs were therefore biased towards the insoluble limestone – anhydrite – dolomite fraction.

Figure 4-20. Drillhole profiles, Nappan deposit, Cumberland County. (For locations see Fig. 4-18).

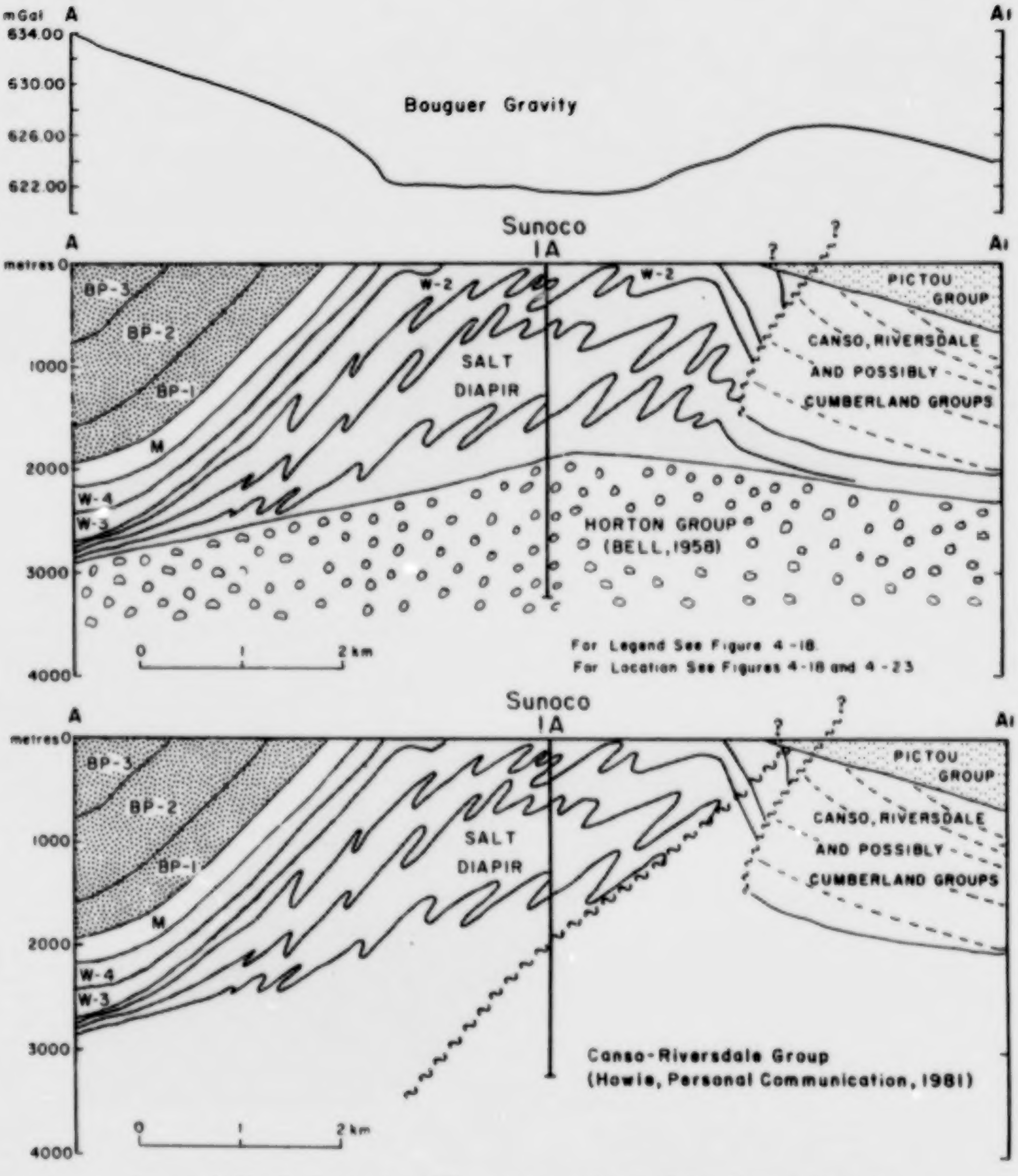

mGal
A
A1
634.00
630.00
626.00
622.00
Bouguer Gravity
Sunoco
1A
?
metres 0
1000
2000
3000
4000
BP-3
BP-2
BP-1
M
W-4
W-3
W-2
SALT
DIAPIR
PICTOU GROUP
CANSO, RIVERSDALE AND POSSIBLY CUMBERLAND GROUPS
HORTON GROUP (BELL, 1958)
0
1
2 km
For Legend See Figure 4-18
For Location See Figures 4-18 and 4-23
Canso-Riversdale Group
(Howie, Personal Communication, 1981)

Figure 4-21. Geological and Bouguer gravity profile, Nappan deposit.

trated at 414.5 m (1360 ft.) and was bottomed at 1809.3 m (5936 ft.). The hole was lost at 1981 m (6499 ft.) and Sunoco No. 1A was drilled 46 m north. Salt was first penetrated at 336.8 m and was bottomed at 1818.1 m. In both holes the salt intervals alternated with gypsum, anhydrite, limestone, and dolomite. The Sunoco No. 1A test was abandoned in 1947 at 3506 m, in strata reported to be part of the Horton Group (Bell, 1958). Howie (personal communication, 1982) reported that Canso-Riversdale Group spores were recovered from this section indicating a reverse or thrust fault with Windsor Group evaporites over younger rocks (Fig. 4-21). It should be noted that the drillhole plots for Sunoco No. 1 and No. 1A (Fig. 4-20) are based upon chip logs which often are multicomponent descriptions and precise correlations are not apparent even though the hole separation is less than 50 m (Goodman and Pendle, 1955).

The latest drilling in the area by Gulf Oil Canada Ltd. in 1975 (Fig. 4-18) penetrated the entire Carboniferous section present (Fig. 4-22), but did not intersect salt. In this area the Windsor Group is apparently not present because of onlap by younger Carboniferous rocks onto pre-Carboniferous basement.

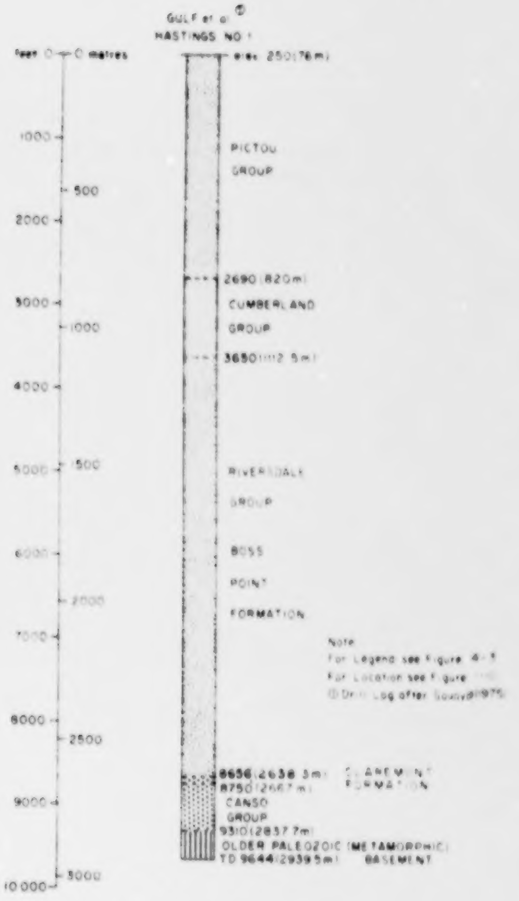

GULF et al ①
HASTINGS NO 1
feet 0
0 metres
elev. 250 (76 m)
1000
500
2000
3000
1000
4000
5000
1500
6000
2000
7000
8000
2500
9000
10 000
3000
PICTOU
GROUP
2690 (820 m)
CUMBERLAND
GROUP
3650 (1112.5 m)
RIVERSDALE
GROUP
BOSS
POINT
FORMATION
Note
For Legend see Figure 4-1
For Location see Figure
① Drill Log after Sounyo 1975
8656 (2638.3 m)
CLAREMONT
FORMATION
8750 (2667 m)
CANSO
GROUP
9310 (2837.7 m)
OLDER PALEOZOIC (METAMORPHIC)
BASEMENT
TD 9644 (2939.5 m)

Figure 4-22. Drillhole profile, Gulf et al., Hastings No. 1, Cumberland County.

GEOPHYSICS

The area in the vicinity of the Nappan deposit is included on portions of the Nova Scotia Research Foundation Bouguer anomaly maps 21H/09 and 21H/16 at a scale of 2 inches equals one mile (Fig. 4-23). A high amplitude Bouguer gravity low coincides closely with the Windsor Group outcrop area and it is apparent that these abnormally thickened low density rocks are producing the anomaly. Unfortunately, downhole geophysical logging was not available at the time the oil wells were drilled by Imperial Oil and Sun Oil Company for they probably would have fascilitated more confident interpretations of the lithologic succession.

GEOCHEMISTRY

Several samples from the Amherst No. 1 well were analyzed by Imperial Oil Ltd. and the results are presented in Tables 4-5 and 4-6.

Baar (1966) studied the bromine geochemistry of salt deposits in Nova Scotia as part of the 1966 Potash Project. Cutting samples available from Sunoco No. 1A were analyzed to determine the weight per cent Br/NaCl which were used as indicators of the degree of concentration of the depositional brines. The results of the analyses are presented in Figure 4-24. He concluded that the apparent increase of bromine with depth in the well indicated concentration degrees which may have reached potassium salt precipitation.

ECONOMIC CONSIDERATIONS

The Amherst No. 1 well indicates there is some potash associated with the Nappan salt deposit. The salt occurs as a diapiric core in the Minudie Anticlinorium. Deep oil wells drilled in the area indicate a total salt section thickness in the order of 1400 m. Analyses of borehole cutting samples from Amherst No. 1 yeild NaCl contents of approximately 96.6% at depths below 600 m, however the salt is not as pure in the shallower intervals. The lateral extent of the deposit has not been fully defined, but the gravity data and inferred geology, indicate the salt probably underlies the broad portion of the core area. Salt springs are not common in the area, but salt water has been reported in some water wells (Hayes, 1931). The Nappan deposit is presently being exploited by Sifto Salt Company Ltd. who is operating a vacuum-evaporating brining plant with annual production of approximately 100 000 short tons.

OXFORD DEPOSIT

The Oxford deposit is located in the vicinity of Oxford (NTS 11E/12), central Cumberland County, Nova Scotia (Figs. 1-10 and 4-25). Oxford is located 35 km southeast of Amherst and 90 km northwest of Truro. The area is readily accessible by paved highways 204 and 321 that connect with the Trans-Canada Highway 104. A branch line of the Canadian National Railway mainline between Truro and Amherst runs from Oxford Junction through to Oxford, 4 km to the north.

The terrain in the vicinity is characterized by gently rolling hills with elevations rarely exceeding 75 m in the Carboniferous Lowlands of northern Nova Scotia.

HISTORICAL BACKGROUND

Very saline salt springs and salt ponds were reported on the southern outskirts of the town of Oxford by Hayes (1931) and Bell (1944). Bell (1944) reported that Black, Slade, Vickery, and Park Lakes are due, in large part, to the dissolution and subsequent collapse of the water soluble Windsor Group evaporites such as gypsum, anhydrite, and salt which apparently underlie a large part of the area south of Oxford.

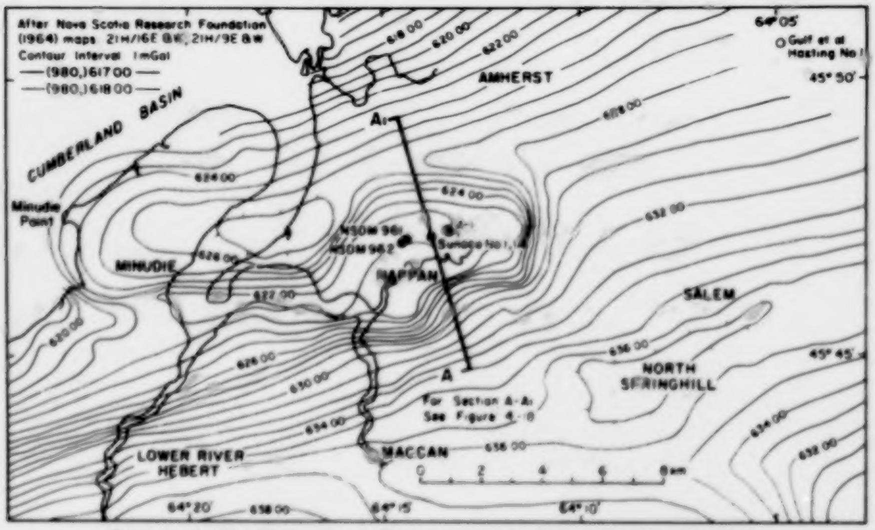

After Nova Scotia Research Foundation (1964) maps 21H/16E B.W., 21H/9E B.W
Contour Interval 1mGal
(980,)617.00
(980,)618.00
CUMBERLAND BASIN
Minudie Point
MINUDIE
AMHERST
NAPPAN
SALEM
NORTH SPRINGHILL
LOWER RIVER HEBERT
MACCAN
NSDM 961
NSDM 962
Sunoco No.1
Gulf et al Hasting No.1
A
A₁
For Section A-A₁ See Figure 4-18
618.00
620.00
622.00
624.00
626.00
628.00
630.00
632.00
634.00
636.00
638.00
0 2 4 6 8 km
64°20'
64°15'
64°10'
64°05'
45°50'
45°45'

Figure 4-23. Bouguer gravity anomaly map, Nappan deposit.

Table 4-5. Analyses of salt samples, Amherst No. 1, Nappan deposit (in per cent)*

Depth (ft.)	Na	K	Ca	Mg	Cl	Si	Fe_2O_3 + Al_2O_3	SO_4	Moisture
1731-61	36.10	0.58	1.41	trace	56.30		trace	3.43	2.04
1820	32.20	0.19	4.34	trace	52.10	-	0.32	7.83	2.56
1980	35.90	0.64	1.81	trace	56.20	-	trace	4.35	0.63
2223	37.50	0.30	0.25	trace	58.40	-	trace	0.95	0.14
2280	38.24	0.16	0.14	trace	58.99	-	trace	0.81	1.29
2330	38.10	0.28	0.54	trace	59.33	-	0.19	1.50	0.18
2440	37.97	0.23	0.74	trace	59.13	-	0.23	2.00	0.10
2640	38.05	0.40	0.78	trace	59.23	-	0.21	1.90	0.25
3230	36.36	0.62	2.07	trace	57.50	0.66	0.24	3.23	-
3240	38.10	0.83	0.22	trace	59.92	0.17	0.31	0.38	-
3250	38.14	0.76	0.38	trace	59.60	0.13	0.09	0.84	-

*Imperial Oil (1932)

Several diamond-drill holes (NSDM 463, 464, 489, and 490) were drilled for a private concern near Oxford Station. According to Hayes (1931) the drill penetrated nearly vertical dipping interbedded gypsum and red-grey sandstone-shale which are typical of the Windsor Group. Salt water obtained from the drilling was analyzed by the Canadian Government Department of Health (Hayes, 1931). NaCl and $CaSO_4$ were the dominant components.

The Malagash Salt Company Ltd. explored the Oxford area for salt in 1953. Two diamond-drill holes were spudded approximately 3 km southeast of Oxford. The first hole MSC-43 reached a total depth of 125 m (410 ft.). Small amounts of salt in reddish veins and as crystals were reported from 79 m (260 ft.) to the bottom of the hole. A second hole MSC-44, drilled 150 m southwest of MSC-43, to a total depth of 114 m did not contain salt.

Salt intermixed with mudstone and anhydrite was intersected in drillholes AOP-1 and AOP-2 drilled by Amax Potash Ltd. in 1979. These holes were located near the Malagash Salt Company Ltd. drillholes. Potash of unknown grade was reported in association with salt in AOP-1.

GEOLOGY

The geology in the vicinity of the Oxford deposit was mapped by Norman and Bell (1938). Due to the apparent scarcity of outcrop, the precise configuration and relationships of the rocks near the axis of the structure were not known.

In general, the Windsor Group rocks occur in the axial area of the western extension of the Malagash Anticline which trends slightly north of east-west. West of Oxford, it hooks into a northeast-southwest trend near Springhill (Fig. 1-10). A north-northeast trending fault offsets the structure 8 km east of Oxford (Fig. 4-25). This fault apparently extends northward to form the southeastern border of the Roslin structure (Figs. 1-10 and 1-4).

The Oxford portion of the Malagash Anticline is bordered on the south by the Tatamagouche

Table 4-6. Mineral assemblage by conventional combination, Amherst No. 1 (in per cent)*

Depth (ft.)	$CaCO_3$	Na_2SO_4	NaCl	KCl	$CaSO_4$	$CaCl_2$	$MgCl_2$	Fe_2O_3 + Al_2O_3	SiO_2	K_2SO_4	Moisture
980-990	3.00	3.40	73.94	-	6.33	-	-	0.48	13.40	-	0.32
1050	-	-	-	4.50	-	-	-	-	-	-	-
1100	-	-	-	4.42	-	-	-	-	-	-	-
1731-61	-	-	91.82	1.11	4.89	-	trace	trace	-	-	2.04
1820	-	-	81.80	0.36	11.09	3.00	trace	0.32	-	-	2.56
1980	-	-	91.40	1.22	6.17	-	trace	trace	-	-	0.63
2223	-	-	95.30	0.57	0.85	-	trace	trace	-	-	0.14
2280	-	-	97.20	-	0.48	-	trace	trace	-	0.71	12.9
2330	-	-	96.80	0.53	1.84	-	trace	0.19	-	-	0.18
2440	-	-	96.50	0.44	2.52	-	trace	0.23	-	-	0.10
2640	-	-	96.70	0.76	2.65	-	trace	0.21	-	-	0.25
3052	-	-	-	trace	-	-	-	-	-	-	-
3230	-	-	92.25	1.18	4.58	2.00	trace	0.24	0.66	-	-
3240	-	-	96.70	1.58	0.54	0.17	trace	0.31	0.17	-	-
3250	-	-	96.72	1.45	1.19	0.08	trace	0.09	0.13	-	-
3275	-	-	-	trace	-	-	-	-	-	-	-
3460	-	-	-	trace	-	-	-	-	-	-	-
4000	-	-	-	none	-	-	-	-	-	-	-

*Imperial Oil (1932)

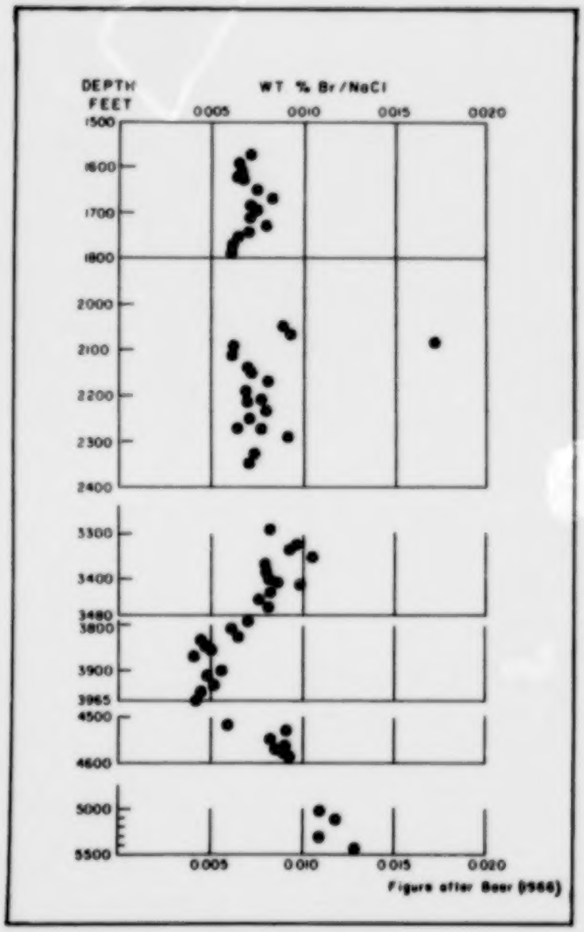


Figure after Baar (1966)

Figure 4-24. Bromine content of halite in Sunoco No. 1A, Nappan deposit.

Syncline (Bell, 1944) which plunges easterly from River Philip toward Tatamagouche (Fig. 1-10). The axial area is occupied by Pictou Group strata. The major stratigraphic units in the Oxford area (Fig. 4-25), include from oldest to youngest according to Norman and Bell (1938): Windsor Group comprising gypsum, red shale, limestone and grey shale; Claremont Formation comprising red conglomerate and grit, some sandstone and shale; Boss Point Formation comprising grey to red interbedded sandstone and shale; Cumberland Group (lower division) comprising red conglomerate and grit, sandstone and shale; Cumberland Group (upper division) comprising grey sandstone and shale, red shale and sandstone, coal; and Pictou Group comprising red sandstone, shale and conglomerate, some grey sandstone and shale.

Norman and Bell (1938) indicated that the Cumberland Group strata rest unconformably upon the Boss Point Formation. A similar situation is apparent on the northern flank of the Malagash-Clairmont Anticline where gently dipping Cumberland Group and Pictou Group strata appear to overlap the Windsor Group in the axial area. The contact between the Windsor and Pictou Groups is mapped on River Philip on the southern side of Oxford. Norman and Bell (1938) indicated that the Pictou Group strata in the area rest disconformably upon the Cumberland Group strata. The area mapped on the northern side of the structure may represent an onlap and overstep situation where Pictou Group strata onlap Cumberland Group strata and both may overstep the Windsor Group, Claremont and possibly Boss Point Formations. The possibility of Windsor Group rocks occurring in an intrusive and faulted relationship may not be ignored however, and indeed that is a highly probable situation. In general, the situation at Oxford is similar (in surface expression) to the Minudie Anticlinorium, but is not as broad. In this respect, it may more closely resemble the western end of the Minudie structure (see Nappan deposit).

The abundance of salt water springs and ponds testifies to the subsurface dissolution of

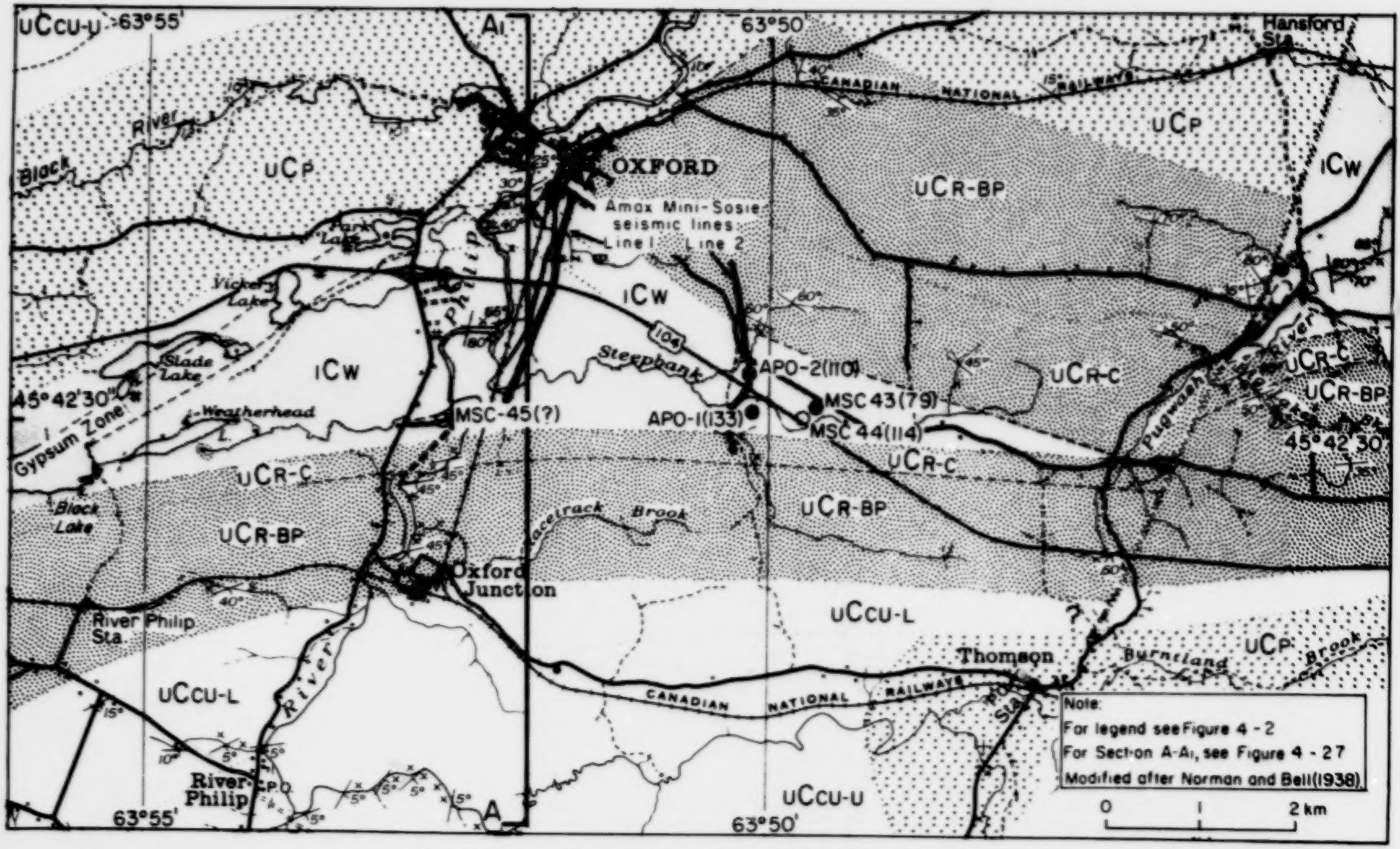

uCcu-u
63°55'
A1
63°50'
Hansford Sta.
Canadian National Railways
uCp
iCw
Black River
OXFORD
Amax Mini-Sosie seismic lines: Line 1 Line 2
uCr-BP
Park Lake
Philip
Vickery Lake
104
Slade Lake
Steepbank
APO-2(110)
MSC 43(79)
APO-1(133)
MSC 44(114)
uCr-C
Pugwash River
Lakes
45°42'30"
Gypsum Zone
Weatherhead L.
MSC-45(?)
Black Lake
Racetrack Brook
Oxford Junction
River Philip Sta.
uCcu-L
Thomson
Burntland Brook
River
River Philip P.O.
A
uCcu-u
Note:
For legend see Figure 4 - 2
For Section A-A1, see Figure 4 - 27
Modified after Norman and Bell(1938)
0
1
2 km

Figure 4-25. Geology in the vicintiy of the Oxford deposit.

salt. Shallow diamond drilling at Oxford in 1924 and 1926 failed to penetrate salt at depths to 91 m (300 ft.). Diamond drilling by the Malagash Salt Company in the eastern end of the Windsor Group in the core axial area in 1953 penetrated salt bearing shales at 79 to 125 m in MSC-43 (Fig. 4-26). The salt is reported to occur as reddish veins and crystals and is apparently secondary in origin. The parent salt mass of these salt veins appears to have been intersected in drilling by Amax Potash Ltd. in 1979 (MacDougall and Polley, 1980). Two holes were drilled less than 1 km west of MSC-43 (Fig. 4-25). The first, APO-1, (Fig. 4-26) intersected overburden and clay-mudstone to 132.6 m (435 ft.) and then salt with clay-mudstone to the total depth at 382.2 m (1254 ft.). Potash (grade unknown) with salt is reported at 209.1-226.8 m (686-744 ft.). APO-2 intersected overburden and clay-mudstone to 110.3 m (362 ft.), then clay-mudstone, salt and anhydrite to the total depth of 623 m (2044 ft.). Potash was not reported in this hole.

A schematic cross-section (A-A_1) through the Oxford occurrence is presented in Figures 4-27 and 4-25. This interpretation is based upon minimal inconclusive subsurface and surface data. The basic structural configuration is interpreted to be a diapiric anticline consisting of Windsor Group evaporites and mudstone. The northern border is believed to be a major fault that has been overstepped by Pictou Group rocks. The exact nature of the southern contact is uncertain but also may be a major fault or shear zone. The Windsor Group evaporites and siltstone-mudstone in the axial area are probably highly deformed.

GEOPHYSICS

Gravity surveys by the Nova Scotia Research Foundation have delineated a Bouguer gravity low anomaly (greater than 10 mGal) that coincides with the Windsor Group in the core of the structure (Fig. 4-28). The centre of the low is located east of the MSC-43 drillhole and the parent salt mass which may be responsible for this anomaly has been proven recently by further deep drilling. In addition to the gravity surveys, Amax Potash Ltd. conducted a shallow penetration reflection seismic survey across two lines near the location of the AOP-1 and -2 drillholes (Roth, 1979a, b). These surveys provide minimal information about the geology of the Windsor Group, but locally are useful in confirming the location of the contacts with younger rocks.

GEOCHEMISTRY

Potash minerals associated with the structure may occur in a similar highly deformed situation to that established in the Malagash Mine and in the Wallace Nos. 1 and 2 holes drilled in the Malagash area 40 km to the east.

Cole (1930a), reported the occurrence of three salt springs present in the Oxford area as follows:

> Oxford Springs (Nos. 9, 10, and 10A). In the park to the southwest of Oxford, Cumberland County, there are a number of saline springs, ponds and wells. At one place on the west side of the road about one mile to the south of the town of Oxford a concrete dam has been built which impounds the water back so that a lake covering several acres has been formed, the water in which is decidedly saline. In the interval to the east of the salt lake and between the highway and the railway there is a spring flowing at the rate of about two gallons per minute (No. 9). On the property of Laurin Thompson, 1/2 mile to the south of the salt lake, two wells have been drilled from which brine is flowing. These wells are about 100 feet apart and they flow into a saline pond of several acres in extent. The first well (No. 10) has a flow from a stand pipe of 1/2 gallon per minute, while the second well (No. 10A) has a flow of one gallon per minute.

The springs were sampled and the analyses reported by Cole (1930a) and are presented in Table 4-7. The waters have similar composition, but spring No. 9 has higher $CaSO_4$ indicating dissolution of significant gypsum in addition to the salt.

Table 4-7. Salt spring sample analyses, Oxford area, Cumberland County*

Sample No.	**9**	**10**	**10A**
FIELD NOTES AT TIME OF SAMPLING			
Temperature of atmosphere, °F	79	79	79
Temperature of brine, °F	46	50	18
Baume degrees	n.d	n.d	n.d.
Equivalent specific gravity	-	-	-
LABORATORY NOTES			
Specifc gravity at 60°F	1.009	1.016	1.0177
Total solids at 110°C	1.32	2.25	2.45
Reaction	None	None	None
ANALYSES OF SOLIDS			
Na .... per cent	27.96	32.97	33.01
K .... per cent	0.09	0.12	0.08
Ca .... per cent	7.41	3.74	3.40
Mg .... per cent	0.11	0.15	0.14
SO_4 .... per cent	16.97	8.44	8.10
Cl .... per cent	44.11	81.79	51.37
Br .... per cent	none	none	none
I .... per cent	none	none	none
Totals...	96.65	97.21	96.10
HYPOTHETICAL COMBINATION			
$CaSO_4$ ...... per cent	24.04	11.94	11.56
$CaCl_2$ ...... per cent	0.94	0.65	-
$MgSO_4$ ...... per cent	-	-	-
$MgCl_2$ ...... per cent	0.43	0.59	0.56
K_2SO_4 ...... per cent	-	-	-
KCl .... per cent	0.17	0.23	0.15
Na_2SO_4 ..... per cent	-	-	-
NaCl .... per cent	71.07	83.80	83.89
Totals...	96.65	97.21	96 16

*Cole (1930a)

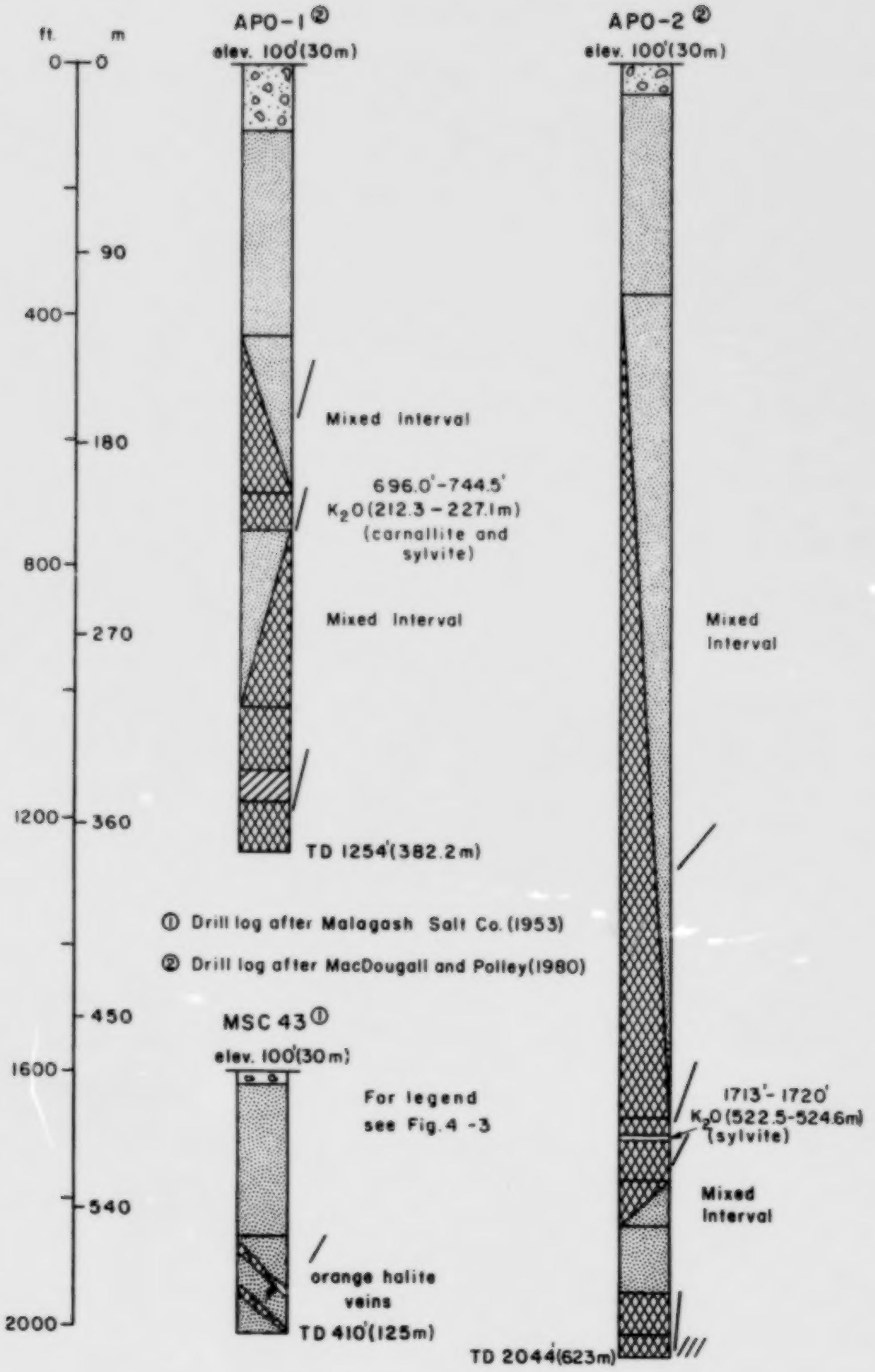
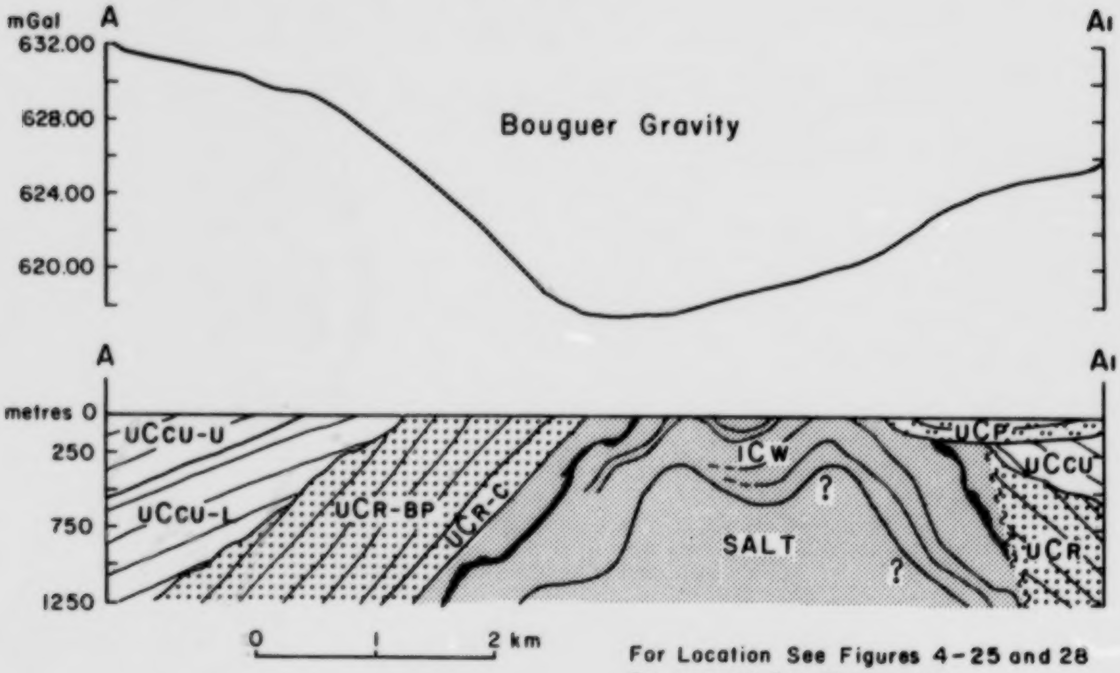

ft.
m
0
0
90
400
180
800
270
1200
360
450
1600
540
2000
APO-1 ②
elev. 100'(30m)
Mixed Interval
696.0'-744.5'
K_2O (212.3 - 227.1m)
(carnallite and sylvite)
Mixed Interval
TD 1254'(382.2m)
APO-2 ②
elev. 100'(30m)
Mixed Interval
1713'- 1720'
K_2O (522.5-524.6m)
(sylvite)
Mixed Interval
TD 2044'(623m)
① Drill log after Malagash Salt Co. (1953)
② Drill log after MacDougall and Polley (1980)
MSC 43 ①
elev. 100'(30m)
For legend see Fig. 4-3
orange halite veins
TD 410'(125m)

Figure 4-26. Drillhole profiles, Oxford deposit. (For locations see Fig. 4-25).



For Location See Figures 4-25 and 28
For Legend See Figure 4-2

Figure 4-27. Geological and Bouguer gravity cross-section, Oxford deposit.

ECONOMIC CONSIDERATIONS

The Oxford deposit consists of orange halite veins and crystals in fractured red shales and salt interstratified with anhydrite and mudstone. A 17.7 m section of mixed potash and salt is reported in one drillhole APO-1 at a depth of 686 m. The area is readily accessible to railway shipping, but is approximately 20 km inland from potential tidewater shipping. Deep drilling has established the presence of a large salt mass and associated potash in the area. The deposit, as it is presently known, is not considered to be of commercial importance, but it does have potential for further potash exploration.

PUGWASH DEPOSIT

The Pugwash deposit is located south and west of Pugwash (NTS 11E/13E), northeastern Cumberland County (Figs. 1-10 and 4-29). Pugwash is readily accessible by paved highways, including Route 6 from Pictou to Amherst, Route 321 approximately 30 km east from Oxford, and Route 368 from Wentworth. A small tide water harbour shipping facility has been built in Pugwash which serves the Canadian Rock Salt Company Pugwash mine.

The Pugwash area is located in the gently rolling countryside of the Carboniferous Lowlands of northern Nova Scotia. Topography in this area rarely exceeds 50 m in elevation and the rivers draining the area have broad estuaries opening to the Northumberland Strait.

HISTORICAL BACKGROUND

The Pugwash area was investigated as part of a regional potash study by Hayes (1931). The area was assessed not to be immediately favourable for potash or salt exploration on the basis of the limited information available at the time. Salt springs indicative of salt and gypsum outcrops were not indicated to occur in the area.

Bell (1944) also considered the area to hold little promise for salt prospecting, because the salt zone was mainly submerged beneath the Pugwash River estuary.

In the 1950's, the Malagash Salt Mine was plagued by mining difficulties and ore grade problems that caused the Malagash Salt Company to explore for a new salt deposit in several areas including Pugwash. Salt was discovered in Pugwash in 1953 when a well drilled for water intersected salt at 137 m (150 ft.). In 1954 diamond drilling was undertaken in the area of the Pugwash inner harbour on the northeastern end of the Pugwash structure. Significant thicknesses of salt were intersected in approximately 7 holes. Based on the success of these diamond-drill Holes, the Malagash Salt Company began sinking a mine shaft in early 1956. By 1959 the shaft was at 219.5 m (720 ft.) with a development level at 192 m (630 ft.). The mine was officially opened on November 4, 1959. Earlier in the year, the Malagash Salt Mine ceased production and was closed. Reserve estimates for the new salt mine were placed at 181.4 Mt (200 million tons).

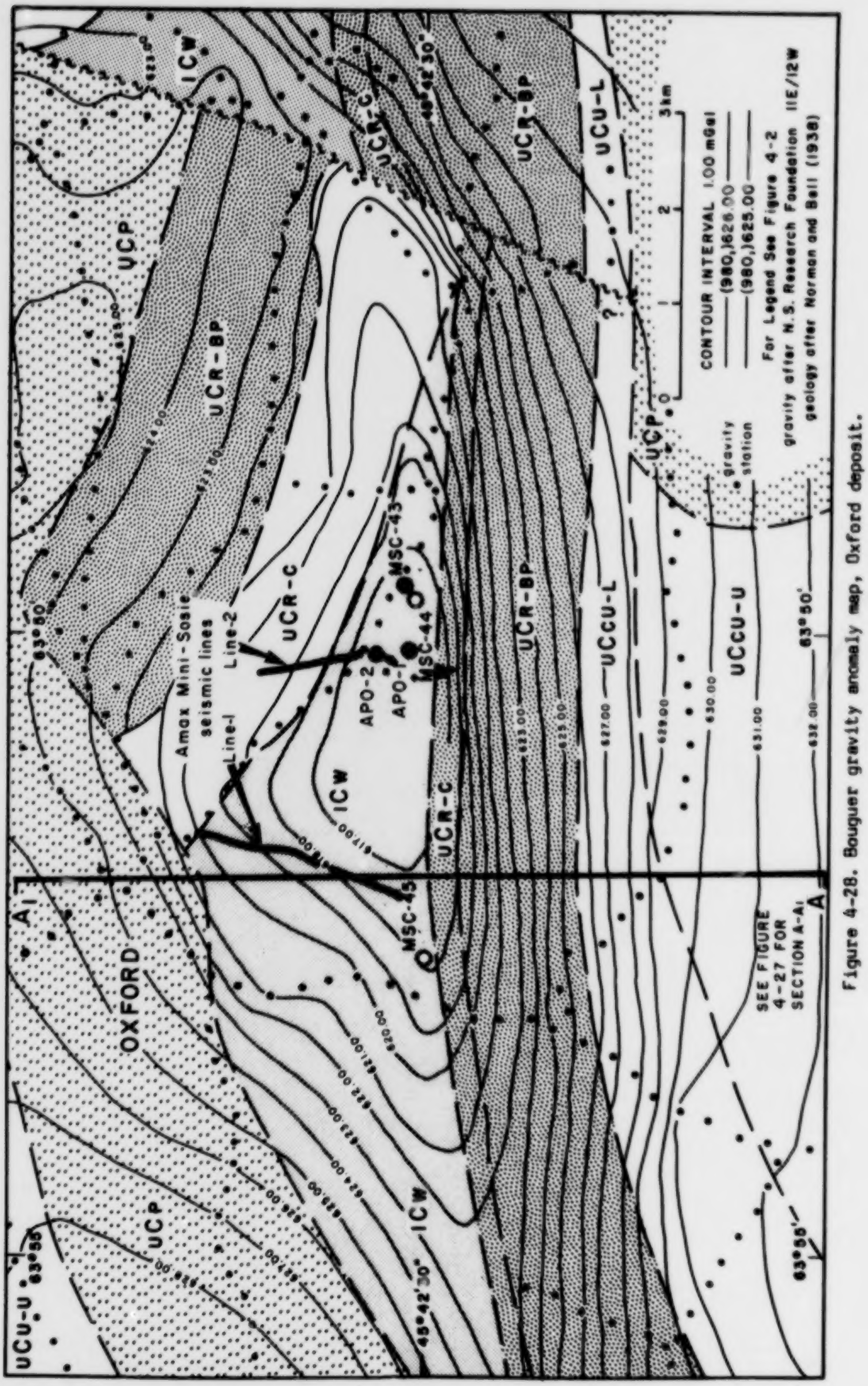
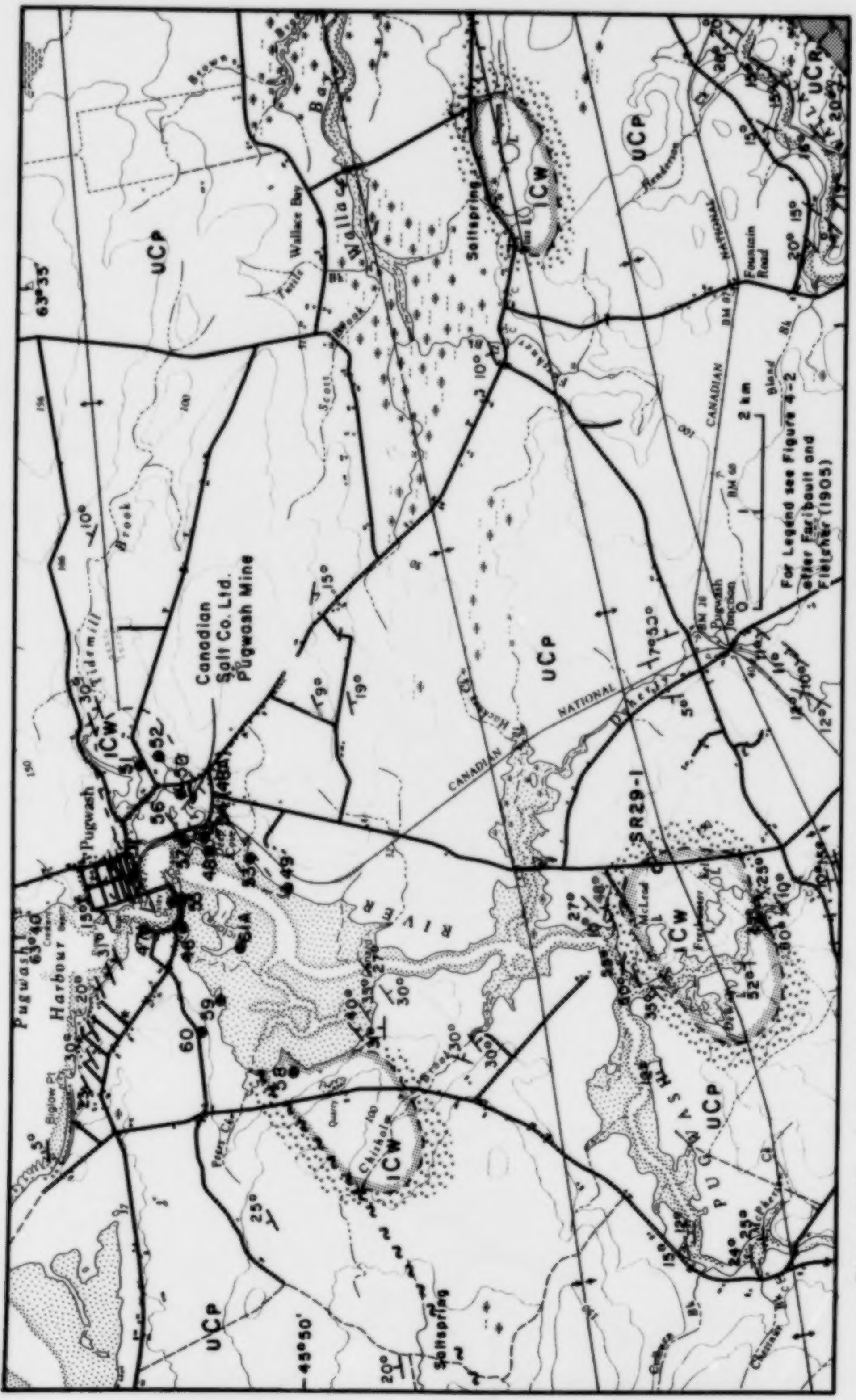

UCU-U
63°55'
45°42'30"
UCP
OXFORD
A1
ICW
UCR-C
MSC-45
Amax Mini-Sosie
seismic lines
Line-1
Line-2
APO-2
APO-1
MSC-44
MSC-43
UCR-BP
UCP
ICW
UCR-C
63°50'
45°42'30"
UCR-BP
UCCU-L
UCCU-U
UCU-L
SEE FIGURE
4-27 FOR
SECTION A-A1
A
63°55'
63°50'
gravity
station
0
1
2
3km
CONTOUR INTERVAL 1.00 mGal
(980,)626.00
(980,)625.00
For Legend See Figure 4-2
gravity after N.S. Research Foundation 11E/12W
geology after Norman and Bell (1938)

Figure 4-28. Bouguer gravity anomaly map, Oxford deposit.


Pugwash Harbour
Pugwash
Canadian Salt Co. Ltd. Pugwash Mine
Tidemill Brook
Wallace Bay
Wallace
Saltsprings
Pugwash River
Canadian National
Pugwash Junction
Fountain Road
Chisholm
Quarry
Scott Brook
SR29-1
UCp
ICW
UCR
63°35'
63°40'
45°50'
2 km
0

For Legend see Figure 4-2 after Faribault and Fletcher (1905)

Figure 4-29. Geology in the vicinity of the Pugwash deposit, Canfield Creek and Simpson Lake, Cumberland County.

In 1961, the Malagash Salt Company reorganized to become the Canadian Rock Salt Company Ltd. and began drilling several new holes at Pugwash to further explore the salt mass. In June 1962 work commenced on a new production shaft 300 feet northeast of the original shaft. The present operation is producing salt at the 250 m (830 ft.) level.

In late 1963 Pacific Petroleums Ltd. spudded Pacific Fox Harbour C-96V (Figs. 4-12 and 4-13) 10.5 km east of the Pugwash Mine. As this was on the eastern extremity of the Minudie Anticline, salt was not intersected in this well until 2678 m (8785 ft.) and continued to 2856 m (9370 ft.). Salt and shale were intersected at 2966 m (9730 ft.) to the final depth at 2981 m (9780 ft.).

GEOLOGY

Faribault and Fletcher, published the first detailed geological map of the Pugwash area in 1905 (Fig. 4-29). This map portrays the Windsor Group (Carboniferous Limestone) as occurring in an elongated ellipsoidal, outcrop pattern whose long axis trends northeast-southwest. The Windsor Group, including limestone, shale, and gypsum in this area is surrounded and overlain by the Pictou Group comprising sandstone and shale. Bell (1944) reported that an unconformable overlap of Pictou Group strata over the Windsor Group red shales is exposed on the Pugwash River estuary "nearly a mile east 56 degrees south from the bridge over Peers Creek." Here basal grey conglomerate about one foot thick is overlain by light grey to purplish grey sandstone striking 066° and dipping 30° southeast. This section overlies unconformably, red shales of the Windsor Group striking 020° and dipping nearly vertically. Approximately 450 m to the northwest of this section, a limestone unit of the Windsor Group is found in a quarry at Dewar Hill. Bell (1944) assigned this to the B Subzone. He indicated this unit has a strike of 142°, dips 86° northeast and was overturned.

He also reported a measured section containing Windsor Group limestone and mudstone from the Dewar Hill quarry area located 4.5 km southwest of the Pugwash Mine.

Bell (1944) reported the shore section east of the quarry comprises vertically dipping or steeply eastward dipping brownish to brick-red and grey-green mudstone and shale with some gypsum stringers. This sequence apparently underlies conformably the overturned limestone section in the quarries and is probably directly underlain in the Pugwash River estuary by the evaporite succession. He estimated this shale section to be approximately 244 m (800 ft.) thick, which corresponds reasonably with a similar stratigraphic unit in the Nappan area.

The northeastern and central part of the Windsor outcrop area is characterized by gypsum outcrop and karst topography. Faribault and Fletcher (1905) mapped a possible fault on the northwestern side of the structure at the contact between the Windsor Group and the Pictou Group (Fig. 4-29). This fault trends northeast-southwest and may extend southwesterly to the Roslin area and form the western border of the Roslin structure. Three diamond-drill holes in this area penetrated Pictou Group sandstone, shale and conglomerate and never reached the Windsor Group.

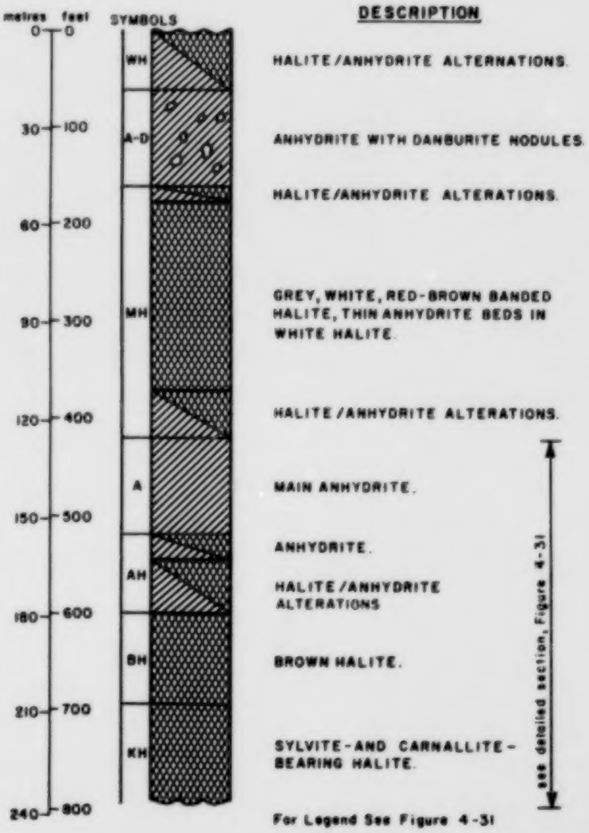
Mine Stratigraphy and Structure

The Windsor Group evaporite rocks occupy the core area of the structure, which has an elliptical topographic outline that may be part of a regional anticlinal trend, or a local domal structure. The Pugwash Mine is situated on the northeastern end of the Windsor Group outcrop area.

The geology of the Pugwash Salt Mine was described by Evans (1967, 1972, and 1974). This work involved detailed studies on the internal structure, mode of deposition, and the stratigraphy of the evaporite rocks forming the Pugwash salt structure.

The stratigraphic column described by Evans (1972) presented in Figures 4-30 and 4-31 can only be considered to be a rough estimate of the

Fig. 4-30 (47 Lines)


metres feet
SYMBOLS
DESCRIPTION
0 0
30 100
60 200
90 300
120 400
150 500
180 600
210 700
240 800
WH
A-D
MH
A
AH
BH
KH
HALITE/ANHYDRITE ALTERNATIONS.
ANHYDRITE WITH DANBURITE NODULES.
HALITE/ANHYDRITE ALTERATIONS.
GREY, WHITE, RED-BROWN BANDED HALITE, THIN ANHYDRITE BEDS IN WHITE HALITE.
HALITE/ANHYDRITE ALTERATIONS.
MAIN ANHYDRITE.
ANHYDRITE.
HALITE/ANHYDRITE ALTERATIONS
BROWN HALITE.
SYLVITE-AND CARNALLITE-BEARING HALITE.
see detailed section, Figure 4-31

For Legend See Figure 4-31

after Evans (1972).

Figure 4-30. Simplified stratigraphy of the sequence exposed in the Pugwash Mine.

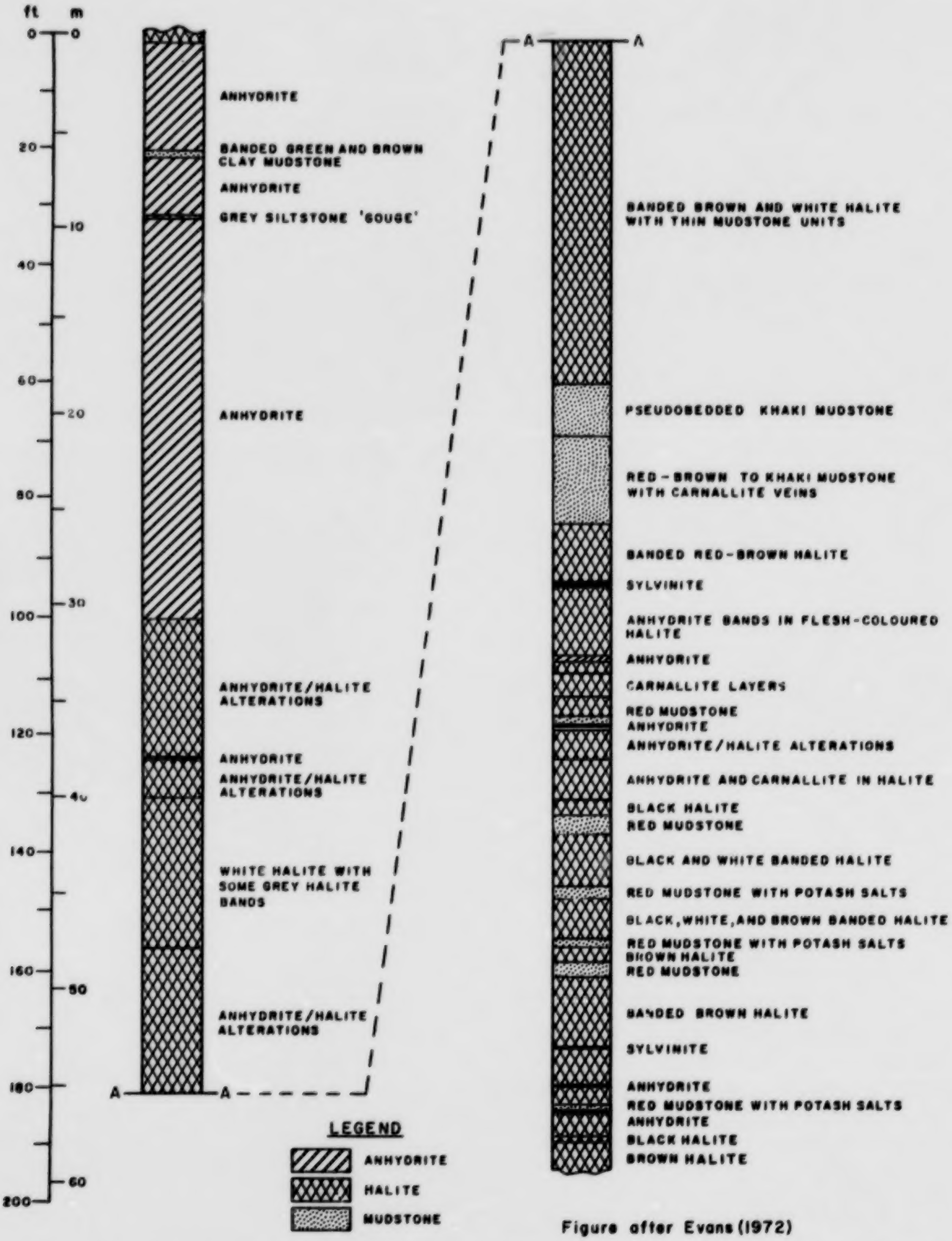

ft
m
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60
ANHYDRITE
BANDED GREEN AND BROWN CLAY MUDSTONE
ANHYDRITE
GREY SILTSTONE 'GOUGE'
ANHYDRITE
ANHYDRITE/HALITE ALTERATIONS
ANHYDRITE
ANHYDRITE/HALITE ALTERATIONS
WHITE HALITE WITH SOME GREY HALITE BANDS
ANHYDRITE/HALITE ALTERATIONS
A
A
A
A
BANDED BROWN AND WHITE HALITE WITH THIN MUDSTONE UNITS
PSEUDOBEDDED KHAKI MUDSTONE
RED-BROWN TO KHAKI MUDSTONE WITH CARNALLITE VEINS
BANDED RED-BROWN HALITE
SYLVINITE
ANHYDRITE BANDS IN FLESH-COLOURED HALITE
ANHYDRITE
CARNALLITE LAYERS
RED MUDSTONE
ANHYDRITE
ANHYDRITE/HALITE ALTERATIONS
ANHYDRITE AND CARNALLITE IN HALITE
BLACK HALITE
RED MUDSTONE
BLACK AND WHITE BANDED HALITE
RED MUDSTONE WITH POTASH SALTS
BLACK, WHITE, AND BROWN BANDED HALITE
RED MUDSTONE WITH POTASH SALTS
BROWN HALITE
RED MUDSTONE
BANDED BROWN HALITE
SYLVINITE
ANHYDRITE
RED MUDSTONE WITH POTASH SALTS
ANHYDRITE
BLACK HALITE
BROWN HALITE
LEGEND
ANHYDRITE
HALITE
MUDSTONE

Figure after Evans (1972)

Figure 4-31. Stratigraphic column of the lower part of the section exposed in the Pugwash Mine.

original beds due to the effects of tectonism. Neither the stratigraphic top nor the base of the Windsor evaporite succession is exposed in the mine. Due to extensive deformation and flowage many salt units have estimated thickness only, while the more competent anhydrite units are measured with some degree of accuracy. In most instances, Evans (1972) concluded that only salt beds in the fold nose could be considered as fairly close to the true thickness. The folding and refolding in some areas are often so severe that minor layer stratigraphy of the thinner layers was not determinable. This situation was well illustrated in the southeastern part of the mine area as shown on Figures 4-32 and 4-33. Evans (1972) also indicated that the fracturing of the thick anhydrite beds (main and danburite nodule) during the deformation and intrusion has, in some areas, produced a mixing of the stratigraphic units. The true sequence therefore was not readily determinable.

The evaporite sequence in the Pugwash structure is dominated by anhydrite and halite which occur both as thick beds and as interbedded intervals that are transitional into the thick beds (see frontispiece). The lower part of the stratigraphic column in the mine is characterized by the scarcity of anhydrite, the predominance of brown to black halite and the appearance of red mudstone with potassium salts. Sylvinite, a mixture of halite and sylvite, is also indicated at two horizons at this level. Evans (1972) attributed the halite colouration to finely disseminated red and brown clay.

The contact between the mine stratigraphic section described by Evans (1972) and the section of the Windsor Group described by Bell (1944) in the Dewar Hill area to the southwest is probably a fault.

The complex structural configuration of the evaporites in the Pugwash mine as mapped by Evans (1967, 1972) (Figs. 4-32 and 4-33) is the best detailed documentation of the stratigraphy of any salt intrusive in Nova Scotia. This complicated structure was not apparent or appreciated in the initial surface diamond-drill exploration (Figs. 4-29 and 4-34). Evans (1972) concluded that the fold configuration and severity of deformation were similar to the structural configuration of diapirs, but suggested the Pugwash structure is intermediate between piercement diapirs and deformed anticlines.

Three distinct fold trends are described in the Pugwash structure by Evans (1972). One trend is parallel with the peripheral Pennsylvanian cover fold axis trend. A second trend is approximately perpendicular to the first. Both trends are attributed to the influence of the Pennsylvanian structure on the growing diapir. Interfering fold patterns resulting from a blending of compressive forces are reported to occur in the centre of the structure. A third trend, oriented slightly southeast, is found in folds near the northwestern border of the structure. He reported that a plot of the measured fold axes from the Pugwash Mine shows a radial arrangement which is characteristic of dome type diapiric intrusions. Most of the folds in the halite units of the Pugwash structure, are similar and quasi-similar folds with steeply dipping axial planes and parallel to subparallel isoclinal limbs. Thin anhydrite interbeds have parallel geometry. Evans (1972) reported that refolding of these tight folds has produced complex fold forms with closures, crescent-shaped closures and "hooked" fold forms common. These interfering fold forms are attributed to a single continuing deformation rather than separate periods of deformation although the latter is possible. In the folding, the halite responded to the stress in a plastic manner and flowed extensively. The thick anhydrite beds are believed to have, in the early stages, bent under stress until their competence resulted in failure and rupture. These thick beds were broken, dislocated and apparently carried passively as rafts by the flowing salt in the later stages of the structures development. Attenuation associated with the halite flowage was often so severe that it apparently eliminated parts of the sequence.

The unconformable contact between Windsor and Pictou Groups strata described to the southeast of the Dewar Hill quarry is not exposed on the northern side of the structure. Faribault and Fletcher (1905), as previously mentioned, indicated a possible fault along this contact. Several factors must be considered in assessing this contact to determine whether it is an angular unconformity or a faulted intrusive contact. Cross-sections drawn by Evans (1972) in the vicinity of the Pugwash Mine (Fig. 4-33) indicate a relatively sharp contact between the steeply dipping Windsor evaporite succession, occurring stratigraphically below the limestone and shale section at Dewar Hill, and the more gently dipping Pictou Group sandstones. Based on this field evidence, simple angular unconformity with Pictou strata overlapping the Windsor Group evaporites does not seem to be an attractive alternative. The contact between Windsor Group evaporites and the Pictou Group (Fig. 4-33) is very steeply dipping over a vertical interval of 150 m. This dip would be highly unusual between water laid sediments deposited over and against water soluble strata. It is more probable therefore, that a combination of overlap and later faulting are responsible for the present configuration. The growth and development of the Pugwash structure, like other Cumberland area salt structures, appears to have caused sedimentary disconformities, angular unconformities, and overstep relationships in its vicinity. It is probable that the onlapping of Late Carboniferous (Pictou Group) sediments was complete and occurred prior to the breaching of the structure and the subsequent exposure of the soluble strata in the core area. This Pictou Group capping was probably intruded by the mobile evaporite in the core. Eventually, crestal block faulting and erosional processes removed the cover, exposing the evaporite core. Subsequent solution and collapse produced a variably thick residual mud, and insoluble gypsum limestone breccia to cap the evaporite core (Fig. 4-33).

Pugwash Mine

Initial development in the Pugwash Mine used a regular grid, room and pillar method based on an

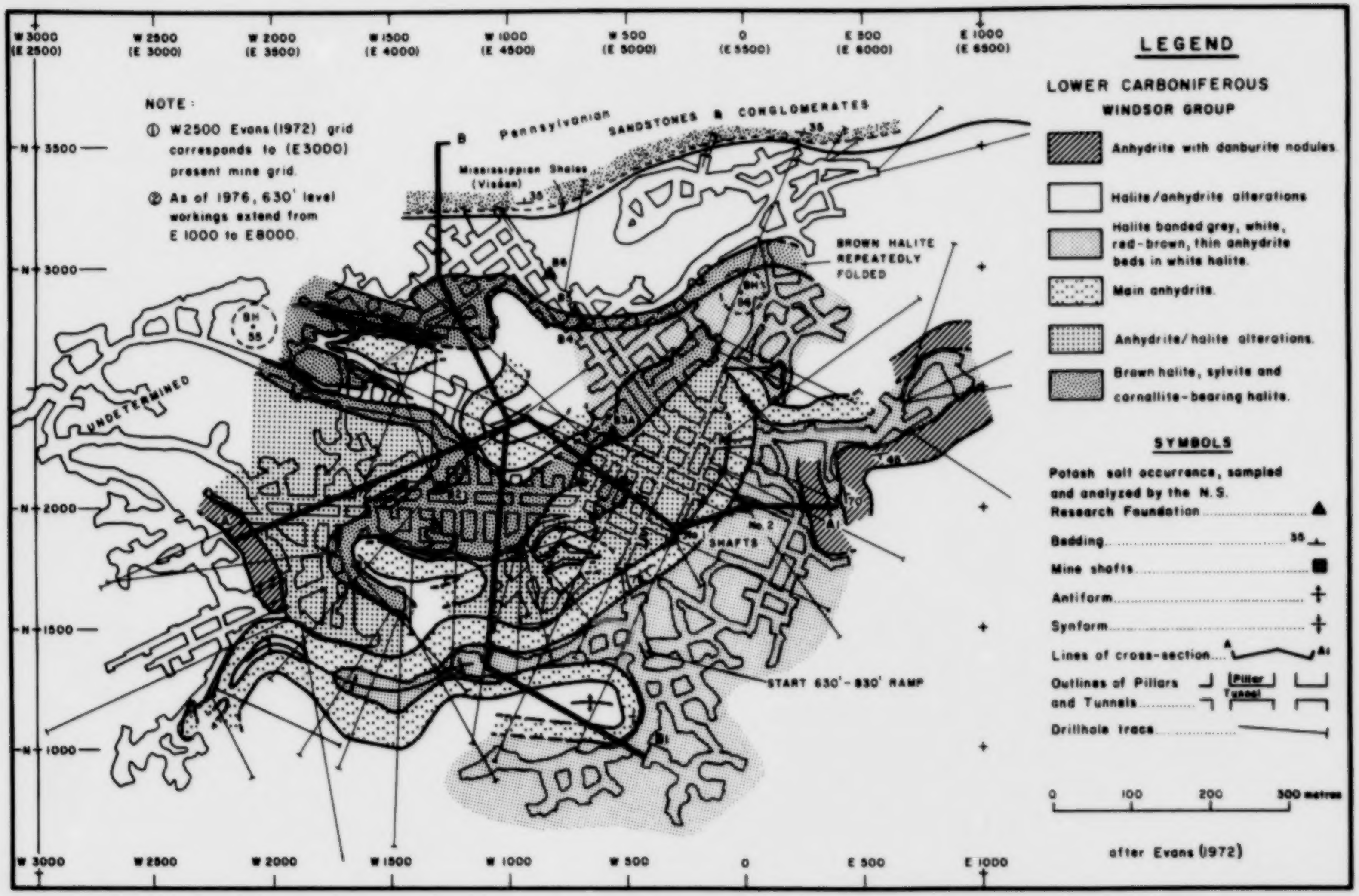
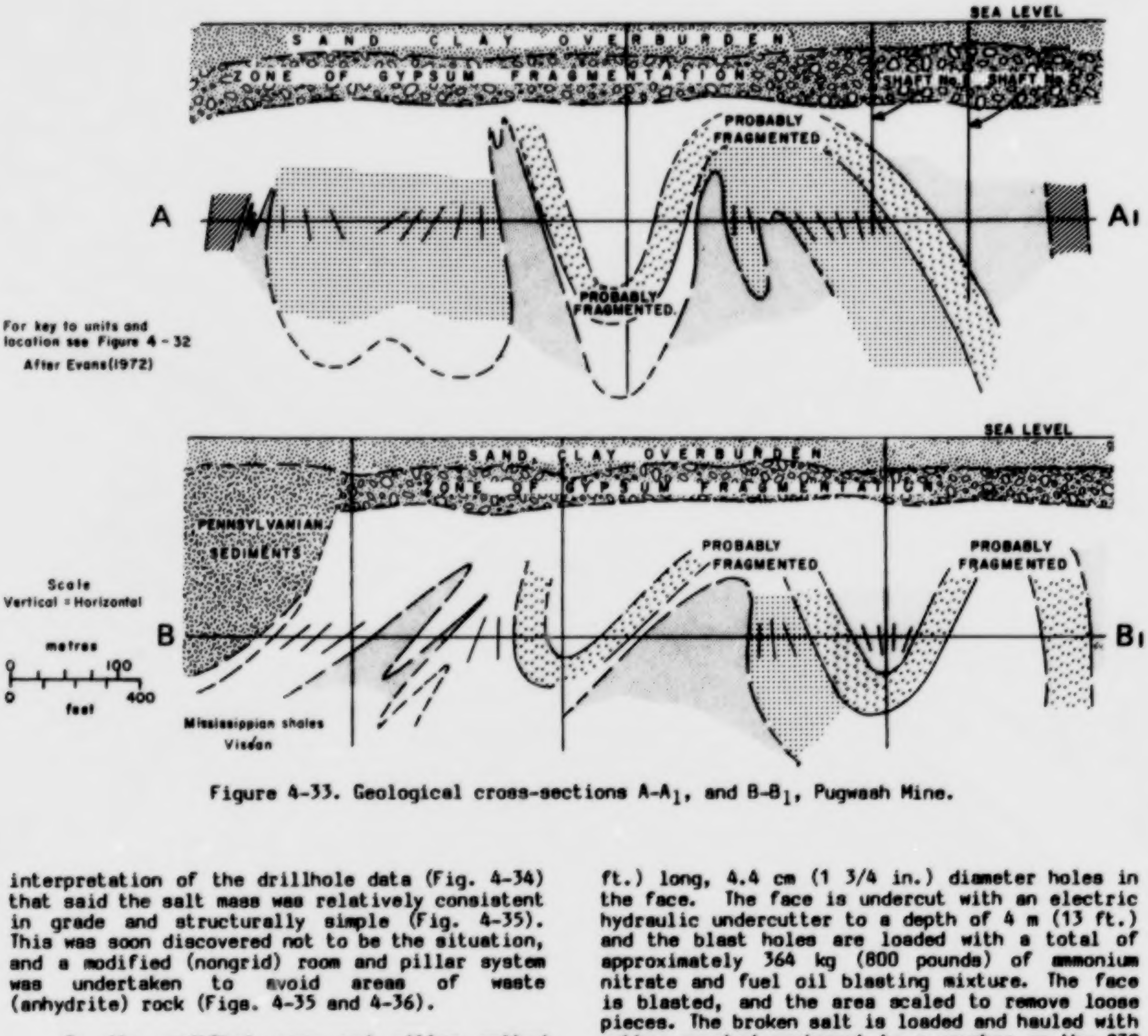

W 3000 (E 2500)
W 2500 (E 3000)
W 2000 (E 3500)
W 1500 (E 4000)
W 1000 (E 4500)
W 500 (E 5000)
0 (E 5500)
E 500 (E 6000)
E 1000 (E 6500)
N 3500
N 3000
N 2000
N 1500
N 1000
W 3000
W 2500
W 2000
W 1500
W 1000
W 500
0
E 500
E 1000
NOTE:
① W2500 Evans (1972) grid corresponds to (E3000) present mine grid.
② As of 1976, 630' level workings extend from E 1000 to E8000.
B
Pennsylvanian
SANDSTONES & CONGLOMERATES
Mississippian Shales (Visean)
35
BH 55
UNDETERMINED
BROWN HALITE REPEATEDLY FOLDED
SHAFTS
No. 2
START 630'-830' RAMP
A
A1
B1
LEGEND
LOWER CARBONIFEROUS
WINDSOR GROUP
Anhydrite with danburite nodules.
Halite/anhydrite alterations
Halite banded grey, white, red-brown, thin anhydrite beds in white halite.
Main anhydrite.
Anhydrite/halite alterations.
Brown halite, sylvite and carnallite-bearing halite.
SYMBOLS
Potash salt occurrence, sampled and analyzed by the N.S. Research Foundation
Bedding
Mine shafts
Antiform
Synform
Lines of cross-section
Outlines of Pillars and Tunnels
Pillar
Tunnel
Drillhole trace
0
100
200
300 metres
after Evans (1972)

Figure 4-32. Simplified geological map and mine plan, 630 foot level, Pugwash Mine, Cumberland County.


SEA LEVEL
SAND CLAY OVERBURDEN
ZONE OF GYPSUM FRAGMENTATION
SHAFT No.1
SHAFT No.2
PROBABLY FRAGMENTED
A
A1
PROBABLY FRAGMENTED
SEA LEVEL
SAND, CLAY OVERBURDEN
ZONE OF GYPSUM FRAGMENTATION
PENNSYLVANIAN SEDIMENTS
PROBABLY FRAGMENTED
PROBABLY FRAGMENTED
B
B1
Scale
Vertical = Horizontal
metres
0
100
0
400
feet
Mississippian shales
Visean

For key to units and location see Figure 4 - 32

After Evans(1972)

Figure 4-33. Geological cross-sections A-A$_1$, and B-B$_1$, Pugwash Mine.

interpretation of the drillhole data (Fig. 4-34) that said the salt mass was relatively consistent in grade and structurally simple (Fig. 4-35). This was soon discovered not to be the situation, and a modified (nongrid) room and pillar system was undertaken to avoid areas of waste (anhydrite) rock (Figs. 4-35 and 4-36).

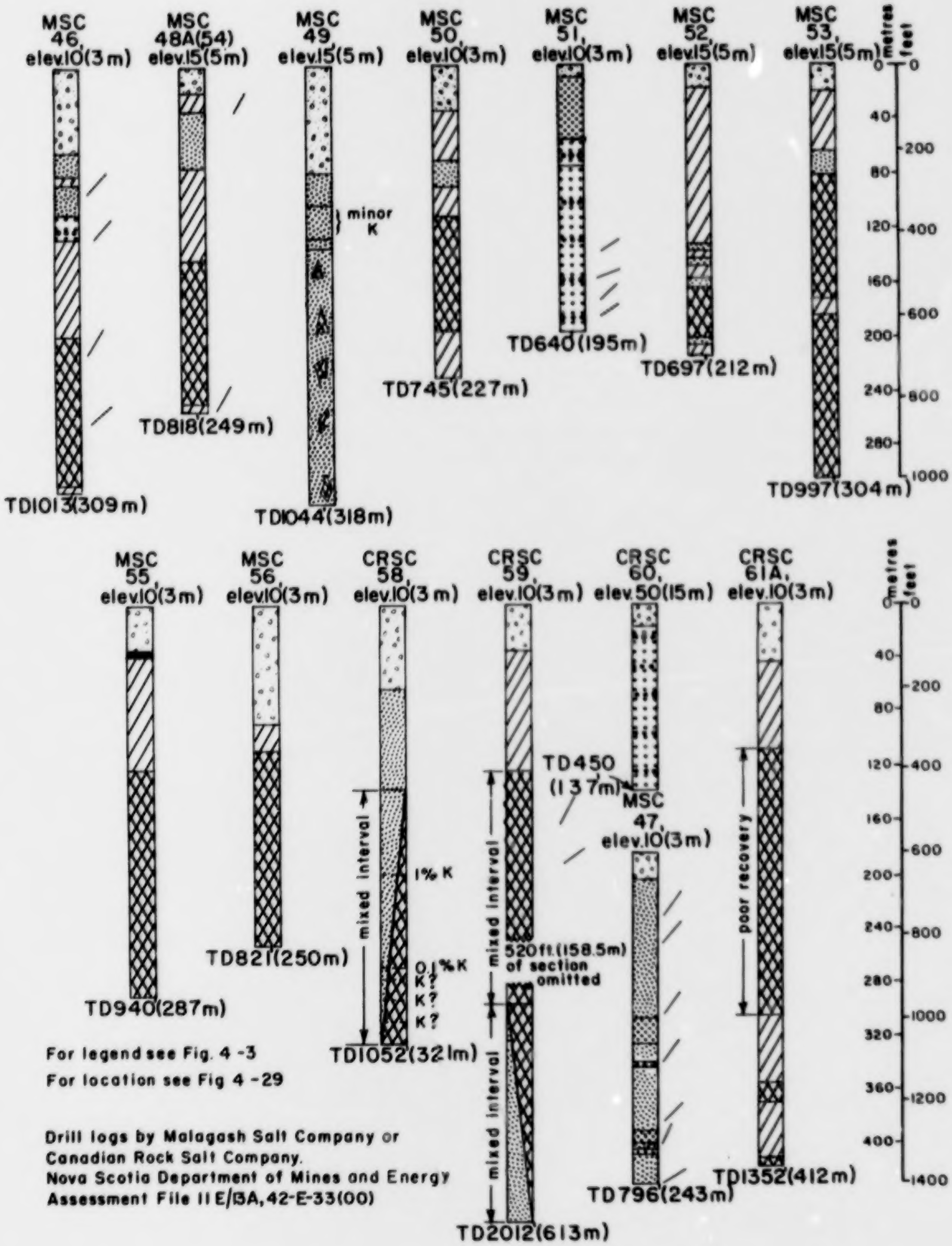
In the modified room and pillar method mining is undertaken between the anhydrite waste bands. Drifts 9.1 m (30 ft.) high by 15.2 m (50 ft.) wide are driven parallel to the waste beds and are separated by pillars 22.9 m (75 ft.) wide. Crosscuts are driven at intervals to connect adjacent drifts.

During the initial development of the 830 foot level, all salt was hauled by truck up a ramp to the 630 foot level for crushing. Hoisting from the 830 foot level through the No. 2 shaft began in November 1975, and now all production and hoisting are handled in this manner. The No. 1 shaft is used for servicing during the production hoisting in the No. 2 shaft.

The mining procedure at the producing face involves drilling approximately ninety 4 m (13 ft.) long, 4.4 cm (1 3/4 in.) diameter holes in the face. The face is undercut with an electric hydraulic undercutter to a depth of 4 m (13 ft.) and the blast holes are loaded with a total of approximately 364 kg (800 pounds) of ammonium nitrate and fuel oil blasting mixture. The face is blasted, and the area scaled to remove loose pieces. The broken salt is loaded and hauled with rubber mounted equipment to a crusher on the 830 foot level. The crushed salt is transported by conveyor to the No. 2 shaft for haulage to the surface in eight ton capacity skips at a rated capacity of 363 t (400 tons) per operating hour.

The rock salt processing involves crushing and screening to remove the anhydrite impurity in two independent parallel circuits. Each circuit is capable of handling over 272 t (300 tons) per hour. In addition, the fines from the mill are transported to an evaporation plant for dissolution to make a feed stock for production of pure fine salt.

The rock salt is loaded and shipped both packaged and bulk via truck, rail and boat to destinations in Eastern Canada. The fine salt is shipped in packages, bulk and as blocks.


MSC 46, elev.10(3m)
TD1013(309m)
MSC 48A(54) elev.15(5m)
TD818(249m)
MSC 49 elev.15(5m)
minor K
TD1044(318m)
MSC 50, elev.10(3m)
TD745(227m)
MSC 51, elev.10(3m)
TD640(195m)
MSC 52, elev.15(5m)
TD697(212m)
MSC 53, elev.15(5m)
TD997(304m)
metres
feet
0
40
80
120
160
200
240
280
200
400
600
800
1000
MSC 55, elev.10(3m)
TD940(287m)
MSC 56, elev.10(3m)
TD821(250m)
CRSC 58, elev.10(3m)
mixed interval
1% K
0.1% K
K?
K?
K?
TD1052(321m)
CRSC 59, elev.10(3m)
mixed interval
520ft.(158.5m) of section omitted
mixed interval
TD2012(613m)
CRSC 60, elev.50(15m)
TD450 (137m)
MSC 47, elev.10(3m)
TD796(243m)
CRSC 61A, elev.10(3m)
poor recovery
TD1352(412m)
metres
feet
0
40
80
120
160
200
240
280
320
360
400
200
400
600
800
1000
1200
1400

For legend see Fig. 4-3

For location see Fig 4-29

Drill logs by Malagash Salt Company or
Canadian Rock Salt Company.
Nova Scotia Department of Mines and Energy
Assessment File 11E/13A, 42-E-33(00)

Figure 4-34. Drillhole profiles, Pugwash deposit, Cumberland County.

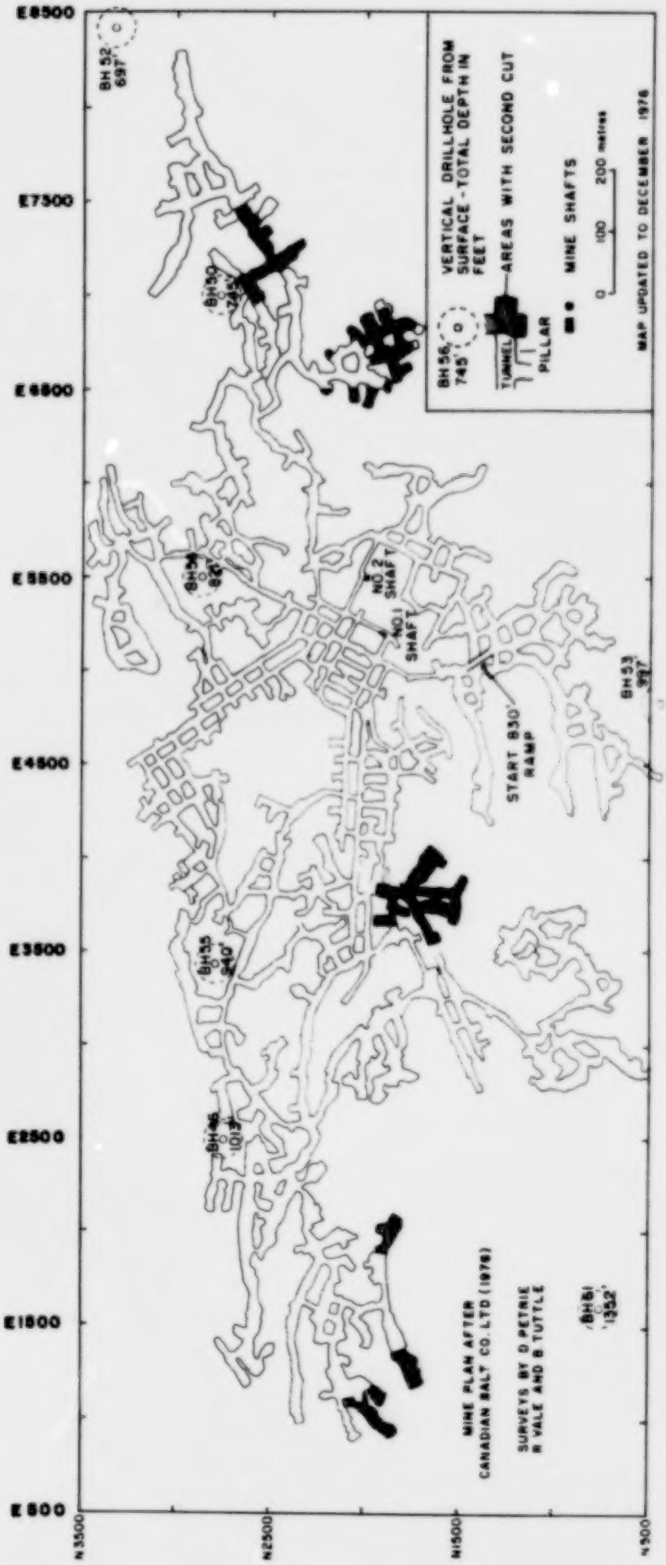

E8500
E7500
E6500
E5500
E4500
E3500
E2500
E1500
E500
N3500
N2500
N1500
N500
BH52 697'
BH50 745'
BH54 821'
NO 2 SHAFT
NO 1 SHAFT
BH53
START 830' RAMP
BH55 940'
BH46 1013'
BH61 1352'
BH56 745'
VERTICAL DRILLHOLE FROM SURFACE - TOTAL DEPTH IN FEET
TUNNEL
PILLAR
AREAS WITH SECOND CUT
MINE SHAFTS
0
100
200 metres
MAP UPDATED TO DECEMBER 1976
MINE PLAN AFTER CANADIAN SALT CO. LTD (1976)
SURVEYS BY D PETRIE R VALE AND B TUTTLE

Figure 4-35. Updated mine plan, 630 foot level, Pugwash Mine.

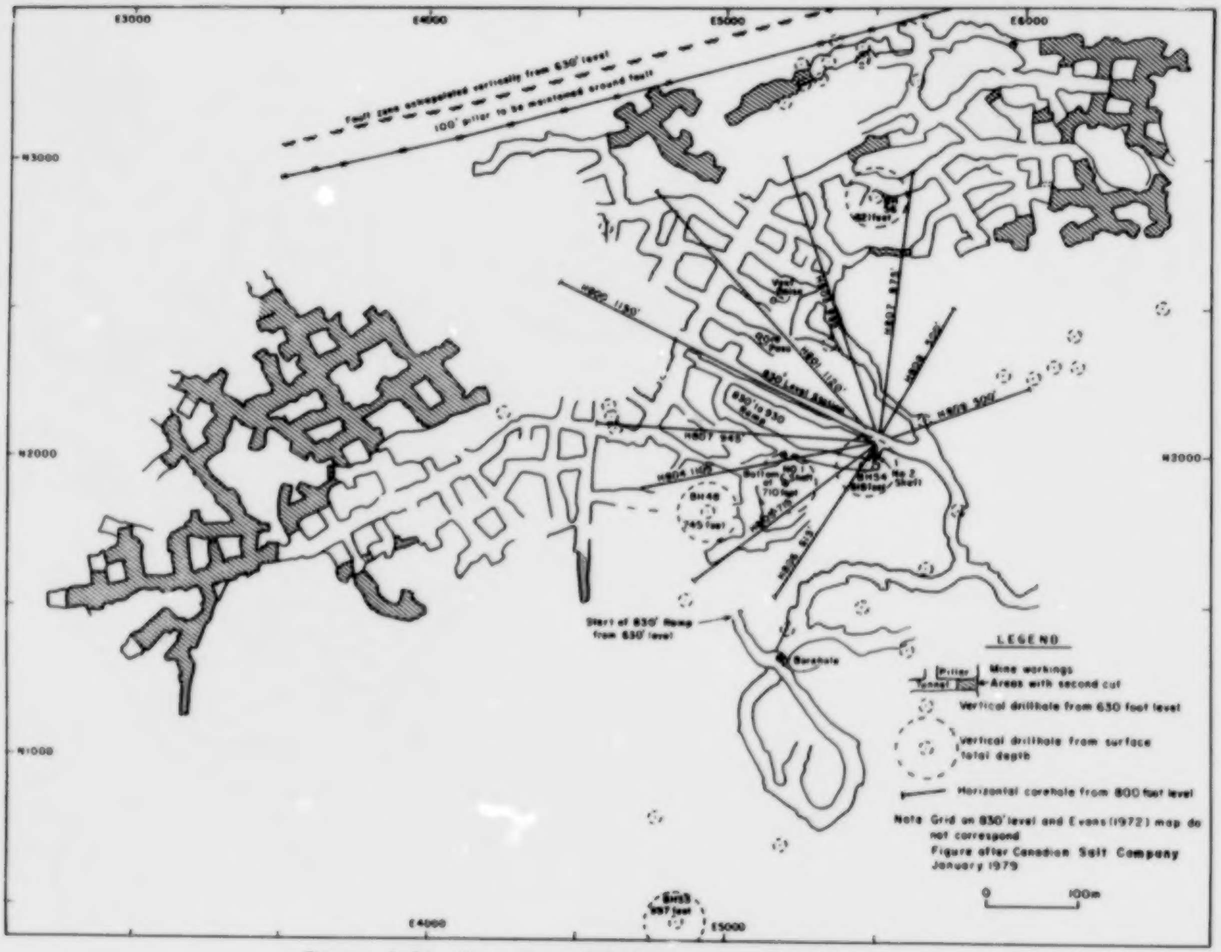

E3000
E4000
E5000
E6000
N3000
N2000
N1000
Start of 830' Ramp from 630' level
Borehole
LEGEND
Pillar
Tunnel
Mine workings
Areas with second cut
Vertical drillhole from 630 foot level
Vertical drillhole from surface total depth
Horizontal corehole from 800 foot level
Note Grid on 830' level and Evans (1972) map do not correspond
Figure after Canadian Salt Company January 1979
0
100m

Figure 4-36. Mine plan, 830 foot level, Pugwash Mine.

GEOPHYSICS

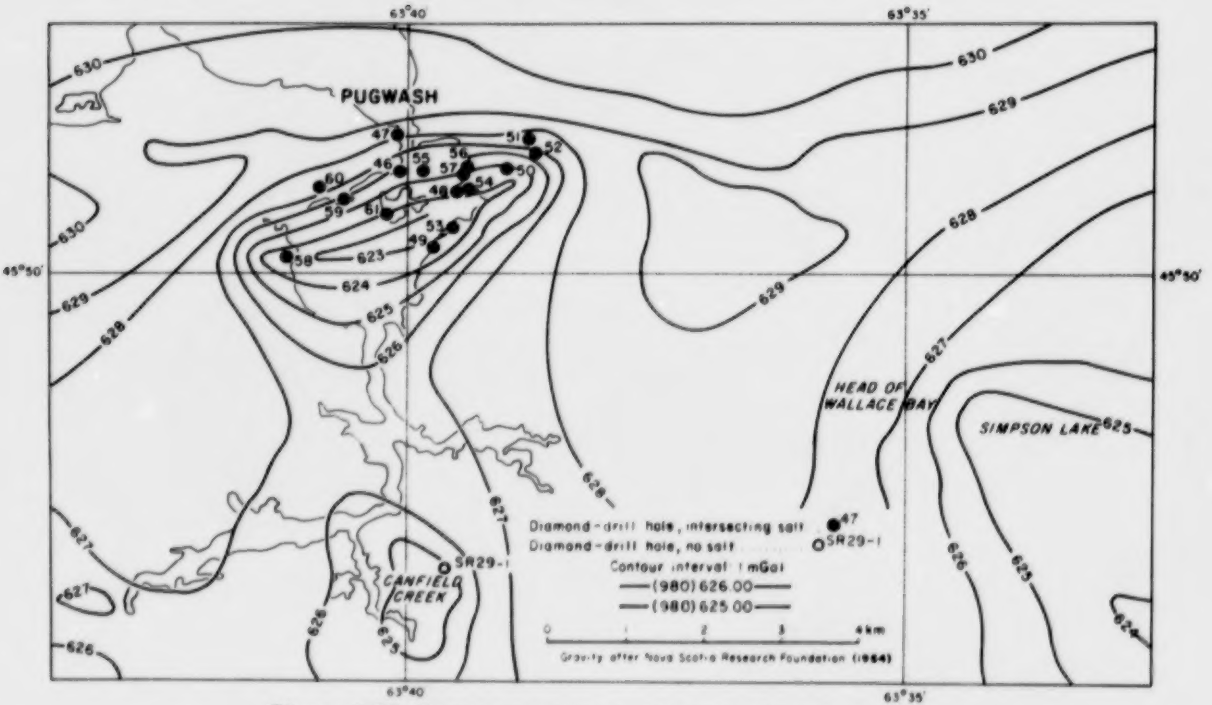
The area in the vicinity of the Pugwash deposit is included on Nova Scotia Research Foundation Bouguer anomaly map 11E/13E (1964) at a scale of two inches equals one mile (Fig. 4-37). A distinct elongate 6 mGal negative Bouguer anomaly coincides generally with the Windsor Group outcrop area.

In 1963 the Nova Scotia Research Foundation ran a down hole gamma ray geophysical log on CRSC-59 drilled by the Canadian Rock Salt Company on the northwestern border of the structure (Figs. 4-29 and 4-38). These surveys helped to locate beds containing potash salts. Figure 4-38 indicates the positive correlation between potash salt intervals and increased gamma ray activity.

GEOCHEMISTRY

The bromine geochemistry of Pugwash deposit was investigated by Baar (1966). He reported large secondary halite crystals occurring in many places throughout the Pugwash Mine could be attributed to solutions mobilized during deformation. This mobilization and recrystallization altered the original bromine content and can place considerable restraints on the application of the bromine geochemical method used in potash exploration. Baar (1966) decided a large scale investigation might reveal the extent of alteration. He selected the Pugwash Mine for detailed sampling because of its unique stratigraphic data control, both perpendicular and parallel to bedding.

He described three potash bearing horizons (carnallite-breccia zones) lying above the uppermost salt unit of Evans (1972) as shown in the stratigraphic column in Figure 4-31. His analyses of bromine in vertical (perpendicular to bedding) and horizontal (parallel to bedding) profiles led to the following conclusions:



Gravity after Nova Scotia Research Foundation (1964)

Figure 4-37. Bouguer gravity anomaly map, Pugwash deposit.

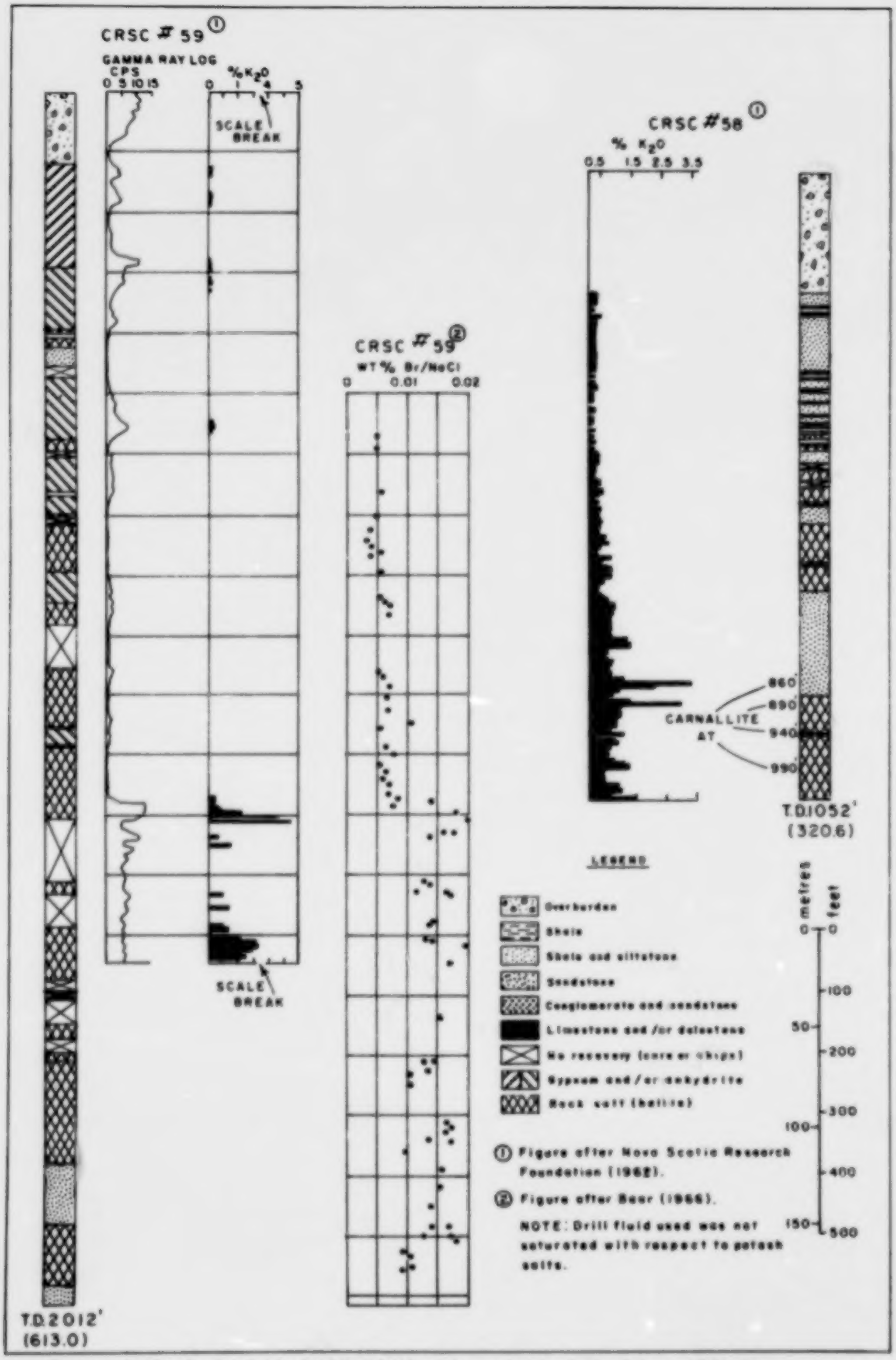
(1) The bromine contents in horizontal profiles of the rock salt beds at Pugwash were not remarkably altered in cases where thicker beds consist of halite with little anhydrite and no thick clay intercalations (Fig. 4-39). Because this rock composition would possess little or no permeability under plastic deformation the measured bromine content is believed to represent the original values.

(2) Bromine contents however were altered in the vicinity of clay partings which were brecciated during deformation. The brecciated clay apparently possessed significant permeability which provided migration routes for the solutions that modified the bromine contents of enclosing halite rocks when disequilibrium existed.

(3) He further concluded that the flat nature of the vertical (stratigraphic) bromine profiles (Fig. 4-40) did not display a trend toward increasing bromine content as might be expected when potash salts were precipitated. This data together with the occurrence of potassium salts in permeable carnallite breccias indicated a secondary origin for the potash from migrating solutions derived from deeper primary sources. Primary potassium salt precipitation apparently did not occur during the deposition of the salt observed in the Pugwash Mine. The abnormally high bromine values recorded were attributable to contamination from adjacent permeable strata containing secondary potash.

Up to 5 weight per cent K_2O were found between 358 and 434 m (1175 and 1425 ft.) in drillhole CRSC-59 located 1.6 km west of mine shaft 1 (Fig. 4-38). Unfortunately, the drill fluid used was not saturated with respect to potash and much of the highly soluble potassium salts were dissolved. Bromine contents below 366 m (1200 ft.) in the drillhole are indicated to be distinctly higher than those in the upper part of the sequence. Primary precipitate values of bromine are indicated just below 366 m and suggest that the potash in this interval could possibly be primary.

In conclusion, Baar (1966) stated that the bromine contents of halite in the Pugwash area indicate the potassium minerals (mainly carnallite) in the upper part of the structure are secondary resulting from precipitation from potassium rich fluids derived from primary mineralization at deeper levels. Because the migrating fluids with a high bromine content were not in equilibrium with halite rock adjacent to the permeable solution channels, alteration haloes were created. Primary potash mineral precipitation (based upon high bromine content) is considered to have been possible only in the lower part of the sequence. Since the secondary potash mineral is mostly carnallite and not sylvite, in the early stages of deformation the source beds consisted mainly of carnallite which on dissolution (more soluble than sylvite) left the sylvite behind. Sylvite should therefore be the dominant mineral in the lower part of the



① Figure after Nova Scotia Research Foundation (1962).

② Figure after Baar (1966).

NOTE: Drill fluid used was not saturated with respect to potash salts.

Figure 4-38. Geological, geochemical and geophysical profiles; CRSC #58 and #59, Pugwash deposit. (For locations see Fig. 4-29).

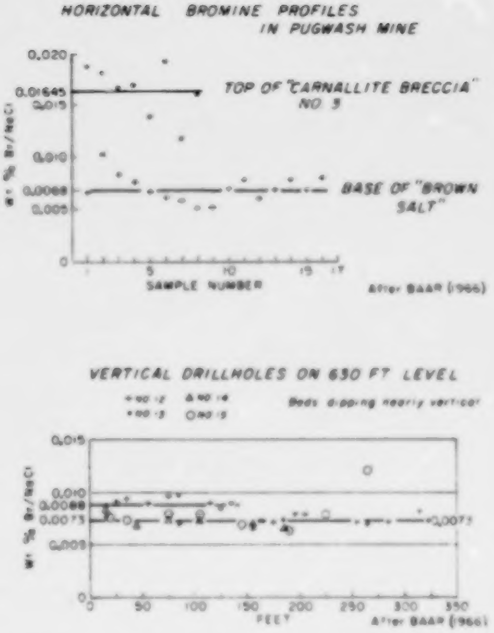


Figure 4-39. Horizontal bromine profiles of stratigraphic units in drill core and mine workings, Pugwash Mine.

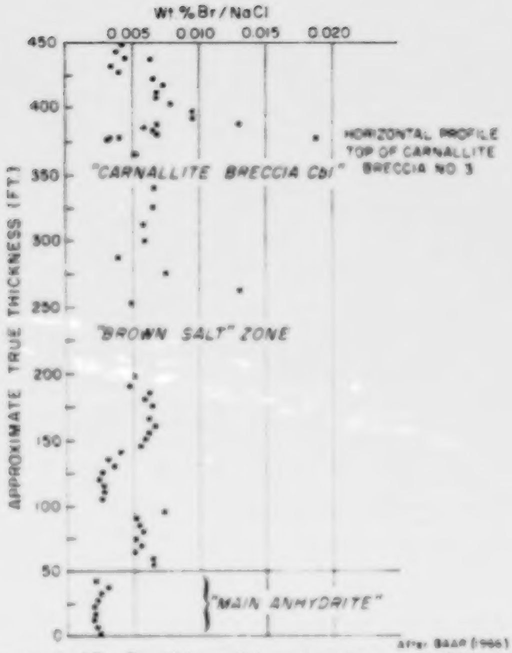


Figure 4-40. Stratigraphic bromine profile of salt units exposed in the Pugwash Mine.

section. It is interesting to note that Evans (1970c) reported sylvite after carnallite in mineralized Wallace No. 1 core from the Malagash deposit and concluded that the sylvite was a secondary product of leaching of primary carnallite.

Nova Scotia Research Foundation (1962) produced a report containing a geology map by Meilke and analyses of potash mineralized zones in the Pugwash Mine (Table 4-8, Appendix 2). Three types of occurrences of carnallite and sylvite were recognized: 1) matrix cement with halite in brecciated clay or mudstone areas, 2) tiny blebs in salt proximal to breccias, and 3) veins or small stringers with orange halite in clay or mudstone. In addition to the potash zones (carnallite breccias) in the Pugwash Mine, potash salts are reported in two diamond-drill holes, CRSC-58 and -59, on the western and northwestern borders of the structure. The analytical results are presented in Figure 4-38 and Table 4-9 (Appendix 2).

Aumento (1964) made a preliminary, but detailed study of the authigenic minerals associated with the Pugwash evaporites. Particular emphasis was placed upon selected samples from the potash salt bearing horizons which were studied with petrographic microscope and X-ray diffraction spectographic techniques on soluble and insoluble fractions and separates. Major rock forming minerals identified include halite, anhydrite, carnallite; intermediate abundances of sylvite, barite, calcite, gypsum, hydro-hematite, magnesite, polyhalite, pyrite and quartz; and trace quantities of acmite-aegerite, boracite, celestite, chlorite, glauberite, goethite, illite?, marcasite?, muscovite, prehnite?, riebekite, rinneite and talc. Details regarding sample sections, preparation and petrology are described by Aumento (1964).

In late 1963, Pacific Petroleums Limited spudded Pacific Fox Habour C-96-V in search of petroleum approximately 11 km east of the Pugwash Mine site (Figs. 1-10, 4-5 and 4-12). Windsor strata were reported to have been intersected at 1673 m (5490 ft.) and salt was first reached at 2678 m (8785 ft.). Approximately 178 m (585 ft.) total thickness of salt was intersected. Table 4-10 records Baar's (1966) reported analyses of cuttings from the salt interval in C-96-V. The bromine content of the salt is high but never reaches the potash threshold of 0.0200.

ECONOMIC CONSIDERATIONS

The Pugwash deposit consists of halite with associated thick and thin beds of anhydrite and thin potassium mineral (carnallite and sylvite) bearing grey shale breccias and local thin sylvinite bands. The salt occurs as intensely deformed beds in a Windsor Group diapiric evaporite intrusion with a general configuration of an ellipsoidal dome containing nearly vertically dipping isoclinal folds. Salt was first intersected at depths between 100 and 130 m and underlies a large portion of the ellipsoidal Windsor outcrop area (3 km x 0.8 km).

Table 4-10. Drill cutting sample analyses, C-96-V, Pugwash area*

Depth		%K	%Br	%NaCl	%Br/100%NaCl
Feet	Metres				
8860	2700.5	0.046	0.0101	99.1	0.0102
8890	2709.7	0.082	0.0106	98.6	0.0108
8915	2717.3	0.125	0.0140	94.9	0.0147
8945	2726.4	0.142	0.0132	92.5	0.0142
8975	2735.6	0.062	0.0132	97.5	0.0135
9065	2763.0	0.068	0.0132	99.9	0.0132
9085	2769.1	0.149	0.0132	97.5	0.0135
9110	2776.7	0.097	0.0107	99.9	0.0107
9135	2784.3	0.082	0.0101	99.9	0.0101
9210	2807.2	0.132	0.0126	99.1	0.0127

*Baar (1966)

In the initial development stages of the Pugwash Mine in 1959, reserve estimates were placed at 181.4 Mt (200 million short tons), although no average grade or recovery ratio were indicated. The production of salt from the Pugwash Mine was slightly less than 1.09 Mt (1.2 million short tons) in 1979. Geological resources based upon 50% halite content in a block 3000 m long, 800 m wide and 300 m thick to a maximum depth of 500 m indicates approximately 725.6 Mt (800 million short tons) of unknown grade.

CANFIELD CREEK

In 1966 Scurry-Rainbow Oil Ltd. undertook a sulphur exploration program in salt structures in Nova Scotia. The Canfield Creek area located 6.5 km south of Pugwash (Fig. 1-10) (NTS 11E/13 East) was selected for diamond drilling (Figs. 4-29, -40, -41 and -42). It was believed to be underlain by a salt structure that was indicated as a negative Bouguer gravity anomaly (5 mGal) coincident with Windsor Group outcrop. A single drillhole, SR29-1, was drilled to a total depth of 420 m (1380 ft.) and penetrated an interstratified section of brick-red sandstone, siltstone, and shale with minor grey shale. The hole was not cored, and bedding dips are not known. Mapping by Faribault and Fletcher (1905; Fig. 4-29) indicated moderately to gently dipping younger (post-Windsor Group) rocks dipping northwest and southeast away from an oblong (2.2 x 1.2 km) core of vertical to steeply dipping Windsor Group red shale, gypsum, and a limestone with a fauna similar to Lime-kiln Brook section bed number 2 (Bell, 1944). Windsor Group gypsum is located several hundred metres south of the drillhole. Bell (1944) indicated the Windsor Group was faulted on three sides against Pictou Group strata (Fig. 4-42). The structure resembles the outcrop pattern of the Pugwash structure (on a smaller scale), but an accurate comparison is not possible with the present data.

A seismic reflection profile through part of the Canfield Creek diapir is interpreted by Bidgood and Blanchard (1967) to be similar to the Malagash-Wallace structure.

HEAD OF WALLACE BAY (SIMPSON LAKE)

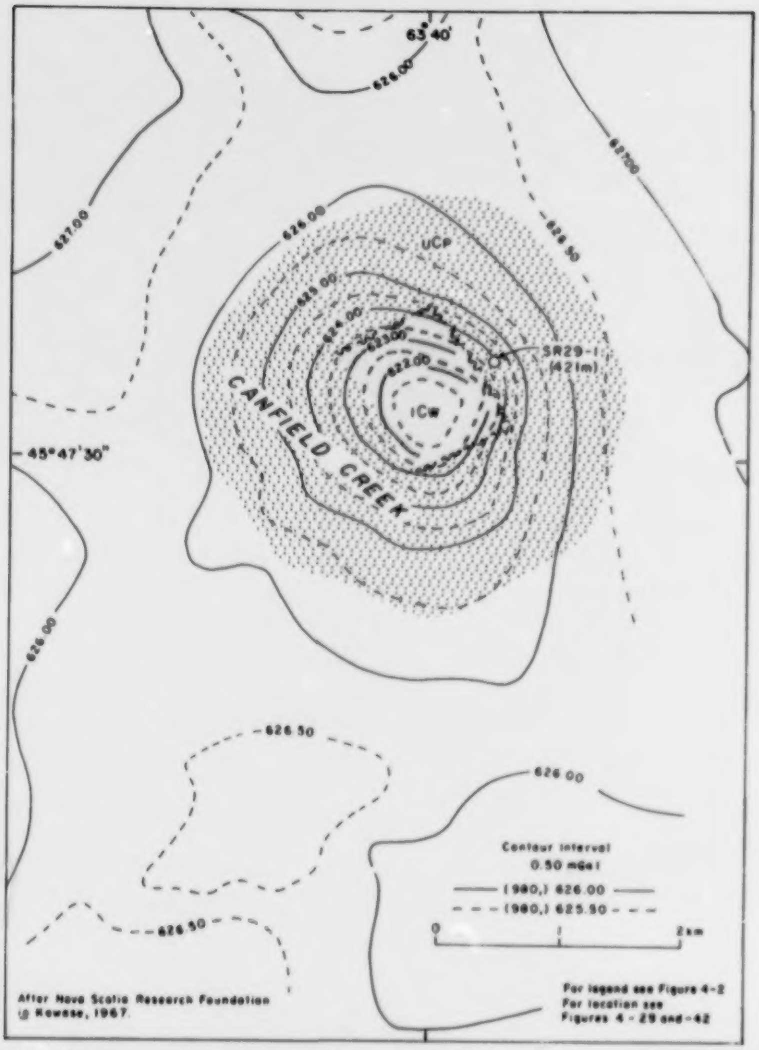
Gravity surveys by the Nova Scotia Research Foundation have outlined a small 4 mGal negative Bouguer gravity anomaly at Head of Wallace Bay near Simpson Lake (Figs. 4-29 and 4-37) approximately 9 km southeast of Pugwash (NTS 11E/13 East) and 8 km west of Wallace (Fig. 4-29). Faribault and Fletcher (1905) indicated an elongated area 1.6 km by 0.8 km mapped as Windsor Group containing sinkholes (gypsum?) and a salt spring. This outcrop area coincides with the gravity anomaly. Although the area has not been drilled, the presence of a small salt structure is suspected.

MALAGASH ANTICLINE BETWEEN WALLACE RIVER AND OXFORD

The portion of the Malagash Anticline between Oxford and the Wallace River (Figs. 1-4, 1-10; NTS 11E/12, 11E/13 East and 11E/14 West) was investigated as part of a regional potash assessment by Hayes (1931). This portion of the structure has not yet been fully explored by deep drilling although Bouguer gravity anomalies coincident with the Windsor Group in the core of the anticlinal structure suggest salt intrusion occurred along its length.

Hayes (1931) reported that the bedding dips of the Windsor Group in this part of the Malagash Anticline are about 35° south. The dips become steeper easterly toward the Wallace River where Faribault and Fletcher (1905) indicated dips of 60-70° south. Hayes, (1931) suggested that the thrust faulting (presumably toward the north) brought the Windsor Group to the surface in an asymmetric anticline. He described the southern contact of the Windsor Group as a conformable onlap of "Millstone Conglomerate" which is probably equivalent to Middleborough and/or Claremont and possibly in part Boss Point Formations of Norman and Bell (1938).

The Windsor Group strata in the axial area have an outcrop width of 0.8 to 1.5 km. Bell (1944) reported that the presence of gypsum in the area is indicated by numerous sinks. Bell (1944) also reported that the Malagash Salt Company drilled a hole at Hartford (Fig. 4-43) to a depth of 46 m (151 ft.). The drillhole reportedly intersected calcareous grey shales containing Lower Windsor fossils. Bedding dips


63°40'
626.00
627.00
626.50
UCP
625.00
624.00
623.00
622.00
SR29-1
(421m)
ICW
CANFIELD CREEK
45°47'30"
626.00
626.50
626.00
626.50
Contour interval
0.50 mGal
(980,) 626.00
(980,) 625.50
0
1
2km
For legend see Figure 4-2
For location see
Figures 4-29 and -42

After Nova Scotia Research Foundation
in Kowese, 1967.

Figure 4-41. Bouguer gravity anomaly map, Canfield Creek, Cumberland County.

are indicated to be about 50° and are similar to those recorded for strata on the southern limb of the Anticline. Faribault and Fletcher (1905) indicated the occurrence of a mineral spring approximately 15 km west-northwest of Hartford. Cole (1930a) reported a salt spring (Conn Brook Spring, No. 7) near Conn Brook, 0.4 km southwest of Hartford (Table 4-11). Pohl (in Hayes, 1931) reported that in 1915 a water well drilled approximately 1.6 km east of Hartford Post Office, produced salt cuttings at a depth of approximately 30 m (100 ft.). In 1921 a water well drilled 0.4 km east of Hartford Post Office produced salt and brine at a depth of 29.6 m (97 ft.).

Cole (1930a) reported the occurrence of four springs in the Hansford area: the East Hansford Spring (No. 15), the Mayne Spring (No. 14), the Conns Brook Spring (No. 7), and the Birchwood Spring (No. 12) (Table 4-11). These springs have a composition dominated by NaCl, but No. 7 and No. 15 have a moderate component of $CaSO_4$ indicating the dissolutuon of gypsum.

Norman and Bell (1938) on Map 410A indicated the east-northeast to west-southwest trend of the Malagash Anticline is offset by a north-northeast trending (transverse) sinistral fault near Hansford, 8 km east of Oxford.

The basic structural situation, together with the presence of salt springs, suggest that salt is probably present in the Hartford-Hansford area, but its presence and depth remains to be proven. Gravity surveys in the area (Fig. 4-1) between Oxford and Wallace River indicate a long

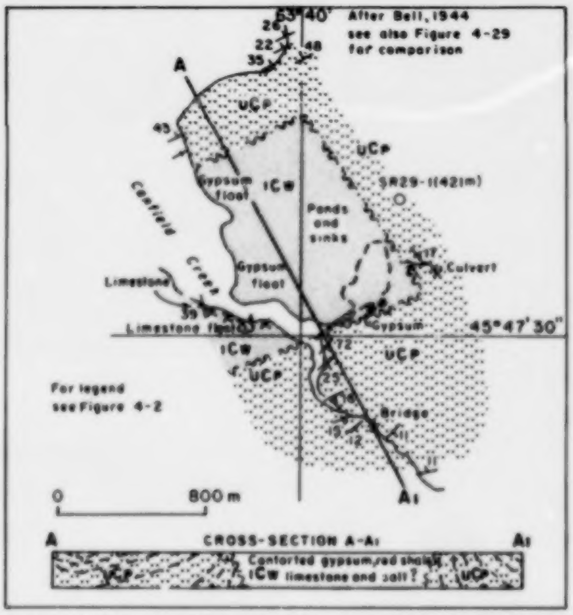

63°40'
After Bell, 1944
see also Figure 4-29
for comparison
A
A1
uCP
lCW
Gypsum float
Ponds and sinks
SR29-1(421m)
Culvert
Canfield Creek
Limestone
Limestone float
Gypsum
Bridge
45°47'30"
For legend
see Figure 4-2
0
800 m
CROSS-SECTION A-A1
Contorted gypsum, red shale
lCW limestone and salt?

Figure 4-42. Geology in the vicinity of Canfield Creek, Cumberland County.

narrow negative Bouguer gravity anomaly coinciding with the axis of the Malagash Anticline. The anomaly magnitude is much less than that of the Malagash-Wallace, Pugwash, Oxford or Roslin anomalies and is interpreted to be caused by deeper and/or smaller salt masses occurring in a similar structural configuration.

SPRINGHILL AREA, BLACK RIVER DIAPIR

The western terminus of the Malagash Anticline occurs near Springhill (Fig. 1-10) where it is faulted against Late Carboniferous strata. To the west of Oxford, the Malagash Anticline changes its trend and forms a hook as it swings northwest, just east of Springhill and then northeast, north of Springhill. Here the Windsor Group is apparently terminated in an east-northeast trending fault. The geology of the Springhill area (Fig. 4-44) was described by Shaw (1951) and Copeland (1959) and more recently by Calder (1980). Shaw (1951) reported that the Windsor Group occurs in restricted areas as gypsum, fossiliferous concretionary limestone and calcareous black shale whose thickness, due to complex structure, is not measurable. In a cross-section, to accompany Shaw's (1951) Preliminary Map 51-11, the Windsor Group at Black River was indicated to occur as a moderate angle thrust or reverse fault in the core of an anticline (Figs. 4-44 and 4-45). Brine springs indicative of subsurface salt dissolution are also

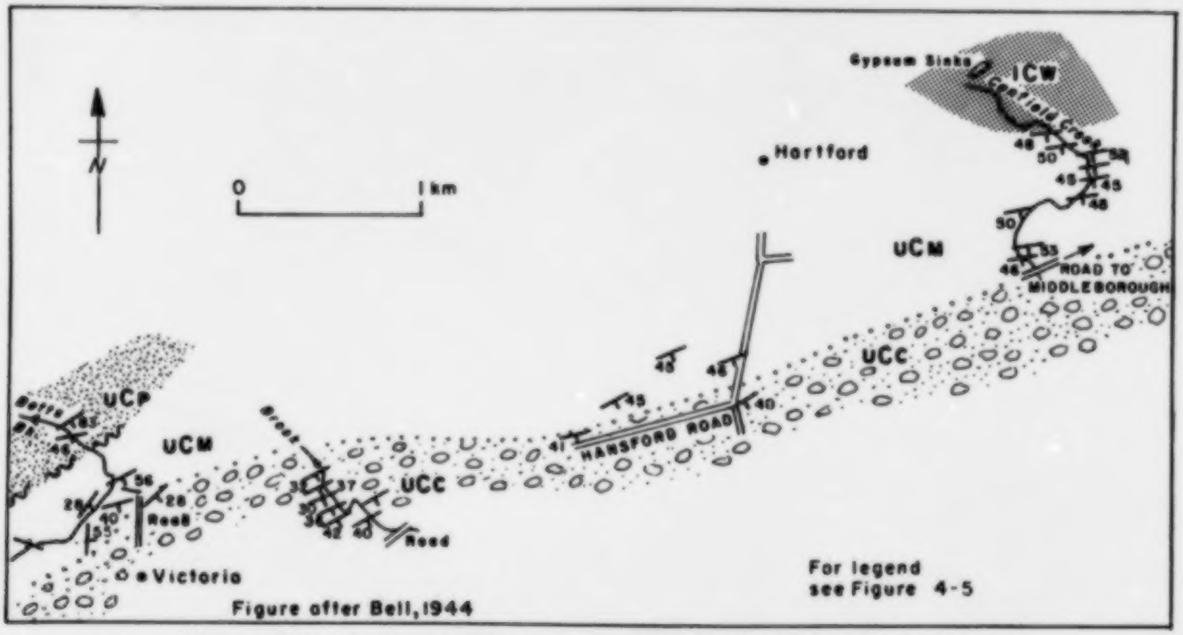

Gypsum Sinks
lCW
Canfield Creek
Hartford
N
0
1 km
uCM
ROAD TO MIDDLEBOROUGH
uCC
HANSFORD ROAD
uCP
Road
Road
Victoria
For legend
see Figure 4-5
Figure after Bell, 1944

Figure 4-43. Geology in the vicinity of Hartford, Cumberland County.

Table 4-11. Chemical analyses of salt springs in the Hartford-Hansford area, Cumberland County*.

Sample No.	7	12	14	15
FIELD NOTES AT TIME OF SAMPLING				
Temperature of atmosphere, °F	75	77	76	76
Temperature of brine, °F	62	50	65	47
Baume degrees	1.5	n.d	n.d	n.d
Equivalent specific gravity .	1.010	-	-	-
LABORATORY NOTES				
Specific gravity at 60°F	1.012	1.0133	1.0005	1.0139
Total solids at 110°C	1.63	1.89	0.71	1.84
Reaction	None	None	None	None
ANALYSES OF SOLIDS				
Na ....Per cent	27.69	35.00	36.50	33.32
K ....Per cent	0.32	0.01	0.22	0.18
Ca ....Per cent	0.16	2.20	0.65	3.82
Mg ....Per cent	0.33	0.21	0.13	0.16
SO_4 ....Per cent	15.94	2.00	0.21	9.23
Cl ....Per cent	45.89	57.11	58.14	51.99
Br ....Per cent	n.d.	none	none	none
I ....Per cent	n.d.	none	none	none
Total	96.33	96.53	95.85	98.70
HYPOTHETICAL COMBINATION				
$CaSO_4$ ....Per cent	20.94	2.83	0.30	13.06
$CaCl_2$ ....Per cent	3.21	3.80	1.55	-
$MgSO_4$ ....Per cent	-	-	-	-
$MgCl_2$ ....Per cent	1.29	0.61	0.51	0.62
K_2SO_4 ....Per cent	-	-	-	-
KCl ....Per cent	0.61	0.02	0.41	0.34
Na_2SO_4 ....Per cent	-	-	-	-
NaCl ....Per cent	70.27	89.28	93.08	84.68
Total	96.32	96.54	95.85	98.70

*L. H. Cole (Table 1, p. 8, 1930a).

reported in the area by Shaw (1951) and Cole (1930a).

In 1941 the Nova Scotia Department of Mines drilled NSDM 931 for special investigation at Black River, near Springhill. The hole was drilled to a depth of 153 m (501 ft.) and penetrated alternating thick beds of red shale and gypsum. Salt was not intersected although salt is indicated in the vicinity by the presence of a salt spring (Salt Springs Spring) 0.4 km to the southeast. The analyses of water from this spring (Table 4-12), reported by Cole (1930a), indicate the major dissolved constituent is NaCl with low $CaSO_4$.

Gravity surveys in the area indicate a narrow negative Bouguer gravity anomaly (6 mGal) coincident with the Windsor Group outcrop area and apparently contiguous with the Oxford anomaly (Fig. 4-1). The presence and extent of salt in the area have not been proven by drilling. Copeland (1959) described the Windsor Group rocks as occurring in a diapiric structure which he called the Black River Diapir.

ROSLIN OCCURRENCE

The Roslin occurrence is located near Roslin (11E/13W), Cumberland County, northern Nova

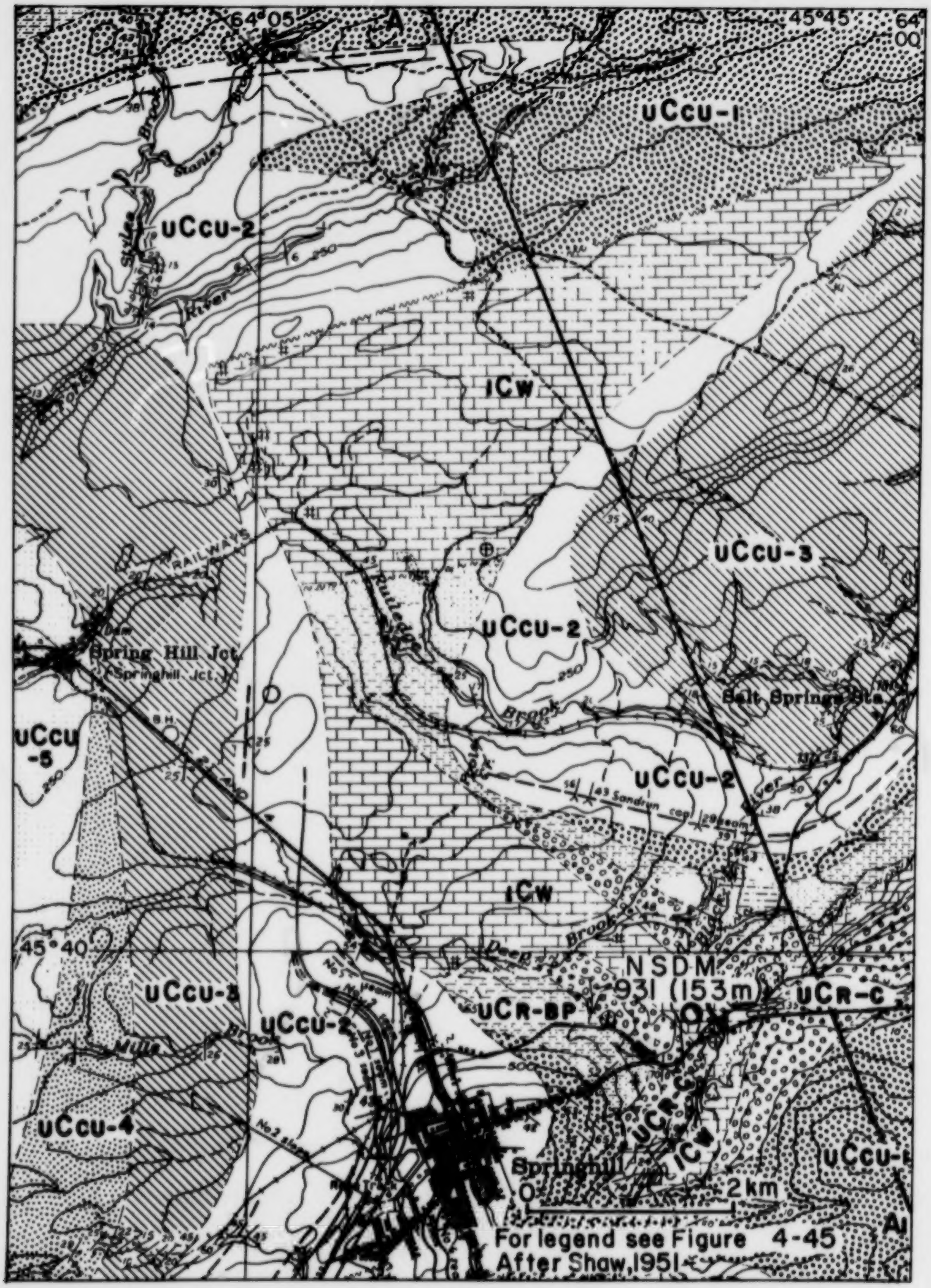

64°05'
45°45'
64°00'
A
uCcu-1
uCcu-2
Stanley
Styles
River
lCw
RAILWAYS
uCcu-3
Spring Hill Jct.
(Springhill Jct.)
uCcu-2
Brook
Salt Springs Sta.
uCcu-5
uCcu-2
Sandrun coal
lCw
Deep
Brook
45°40'
uCcu-3
uCcu-2
Mills Brook
NSDM
931 (153m)
uCr-BP
uCr-C
uCcu-4
uCr-C
lCw
Springhill
uCcu-1
0
2 km
A'
For legend see Figure 4-45
After Shaw, 1951

Figure 4-44. Geology in the vicinity of Black River near Springhill, Cumberland County.

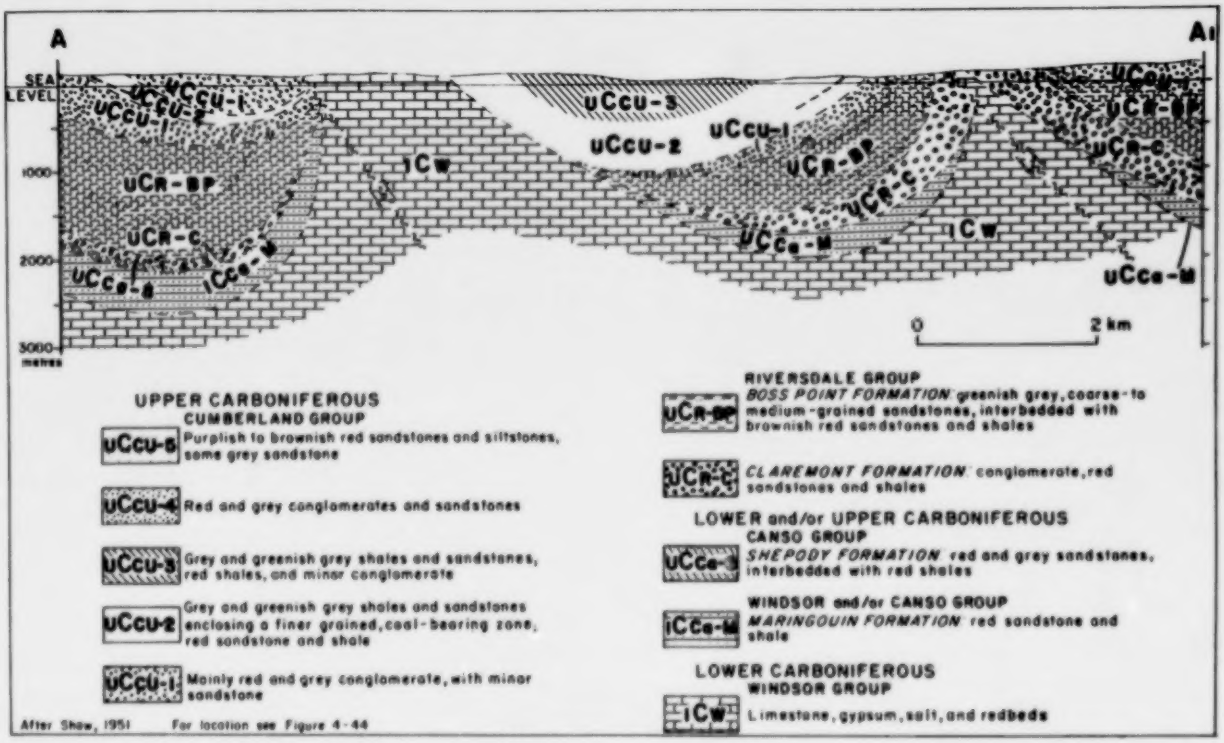

A
A'
SEA LEVEL
1000
2000
3000 metres
uCcu-1
uCcu-2
uCcu-3
uCR-BP
uCR-C
uCCa-S
lCCa-M
lCw
uCCa-M
0
2 km
UPPER CARBONIFEROUS
CUMBERLAND GROUP
uCcu-5 Purplish to brownish red sandstones and siltstones, some grey sandstone
uCcu-4 Red and grey conglomerates and sandstones
uCcu-3 Grey and greenish grey shales and sandstones, red shales, and minor conglomerate
uCcu-2 Grey and greenish grey shales and sandstones enclosing a finer grained, coal-bearing zone, red sandstone and shale
uCcu-1 Mainly red and grey conglomerate, with minor sandstone
RIVERSDALE GROUP
uCR-BP BOSS POINT FORMATION: greenish grey, coarse- to medium-grained sandstones, interbedded with brownish red sandstones and shales
uCR-C CLAREMONT FORMATION: conglomerate, red sandstones and shales
LOWER and/or UPPER CARBONIFEROUS
CANSO GROUP
uCCa-S SHEPODY FORMATION: red and grey sandstones, interbedded with red shales
WINDSOR and/or CANSO GROUP
lCCa-M MARINGOUIN FORMATION: red sandstone and shale
LOWER CARBONIFEROUS
WINDSOR GROUP
lCw Limestone, gypsum, salt, and redbeds
After Shaw, 1951
For location see Figure 4-44

Figure 4-45. Geological cross-section and legend to accompany Black River area geological map, Figure 4-44, Cumberland County.

Scotia (Figs. 1-10 and 4-46). Roslin is situated 7 km northeast of Oxford and 13 km southwest of Pugwash.

The area is readily accessible by paved and unpaved roads. Roslin is located on Highway 21 that runs between Oxford and Port Philip on the Northumberland Strait and is connected to the Trans-Canada Highway 104 that runs through Oxford between Truro and New Brunswick. The mainline of the Canadian National Railway passes through Oxford. Tide water shipping facilities are situated at Pugwash.

The terrain in the vicinity of the Roslin occurrence is typical of the Carboniferous Lowlands in northern Nova Scotia. The area has gently rolling hills with elevations rarely exceeding 75 m. Rivers draining the area have broad estuaries on the Northumberland Strait shore.

HISTORICAL BACKGROUND

The Roslin area was investigated for its potash potential by Pohl as part of a regional study by Hayes (1931). Pohl (in Hayes, 1931) reported a salt spring in the vicinity. Cole (1930a) reported a salt spring near the Roslin Post Office. It is not certain if these reported springs are the same one.

In 1965-1966 the Nova Scotia Department of Mines and Nova Scotia Research Foundation undertook geophysical and geological surveys as part of a potash exploration project in Cumberland County. The program was funded by the Atlantic Development Board and on the basis of these surveys, diamond drilling was initiated on some of the structures including the Roslin structure. One hole, Roslin No. 1 (NSDM 4307) was drilled to a total depth 306 m (1005 ft.). Salt impregnated brecciated red and green mudstone and siltstone were encountered between 114 m and 306 m. No further drilling has been undertaken to penetrate the evaporite section indicated by the Bouguer gravity anomaly.

GEOLOGY

The geology in the Roslin area was first mapped by Faribault and Fletcher (1905). Many occurrences of gypsum and several outcrops of limestone are indicated as occurring in the rectangular outcrop area of "Carboniferous Limestone" or Windsor Group. These evaporites were remapped by Bell (1945) as part of the Windsor Group. The north-northwesterly trending rectangular outcrop of Windsor Group rocks are in fault contact with the Cumberland Group on the west, east and south (Fig. 4-46a). The Cumberland Group comprises grey and red sandstone, grit and conglomerate, and red shale.

Table 4-12. Chemical analyses of Salt Springs, Springhill, Cumberland County*

Salt Springs Spring (No. 11) near Black River

FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere, °F		78
Temperature of brine, °F		54
Baume degrees		n.d
Equivalent specific gravity		-
LABORATORY NOTES		
Specific gravity at 60°F		1.0522
Total solids at 110°C		7.40
Reaction		None
ANALYSES OF SOLIDS		
Na	Per cent	37.22
K	Per cent	0.15
Ca	Per cent	1.08
Mg	Per cent	0.06
SO_4	Per cent	1.55
Cl	Per cent	58.35
Br	Per cent	none
I	Per cent	none
Totals		98.41
HYPOTHETICAL COMBINATION		
$CaSO_4$	Per cent	2.20
$CaCl_2$	Per cent	1.22
$MgSO_4$	Per cent	-
$MgCl_2$	Per cent	0.24
K_2SO_4	Per cent	-
KCl	Per cent	0.29
Na_2SO_4	Per cent	-
NaCl	Per cent	94.48
Total		98.43

*Cole (1930a)

The southwesterly trending fault apparently continues into the Hartford-Hansford area several kilometres to the south. The northern contact is not indicated as a fault, but is apparently an angular unconformity with overlying Pictou Group rocks comprising red sandstone, shale, grit and conglomerate with some grey sandstone and shale. The Pictou Group strata at this location are very steeply dipping and locally overturned near the contact. This suggests the contact is more than a simple angular unconformity. Bell (1944) published a small sketch map of this same area (Fig. 4-46b). He later modified the interpreted structure somewhat on the 1945 map (842-A). The 1944 map (Fig. 4-46b) indicated an east-west trending fault on the northern contact with Pictou Group rocks and marked the eastern contact by a north-south trending fault giving the Windsor Group outcrop area a triangular fault bound outline with the Pictou Group strata.

Rocks of the Windsor Group in the Roslin structure comprise gypsum, limestone, and red shale. A salt spring reported by Cole (1930a) near the Roslin Post Office and diamond-drilling both indicated that salt is also present at depth. Bell (1944) reported that gypsum carrying abundant selenite outcrops on the shore of River Philip near Roslin. Here a strike of 142° and a dip of 38° east is indicated, and he suggested that a string of sinkholes along Plaster Creek may also indicate its presence. He further reported locally fossiliferous limestone and calcareous shale at several localities. Two outcrops of thinly bedded limestone and calcareous shale are located on Plaster Brook. Fossils identified by Bell (1944) from the outcrop 488 m (1600 ft.) southeast of where the Creek crosses the highway are reported to be the same as the Lime-kiln Brook fauna of bed (2). These beds strike 128°, are apparently overturned with dips of 55° to the southwest, and overlie the gypsum horizon. Bell (1944) reported 9.8 m (32 ft.) of calcareous shale and siltstone overlying red shale, at a location 475 m (1500 ft.) southeast of the above locality. Here the beds are vertical, with tops facing to the west and are assigned to the B Subzone. The stratigraphic relationship to the other limestone beds is uncertain.

Diamond drilling (NSDM 4307) undertaken in 1966 as part of the 1966 Potash Project by the Nova Scotia Department of Mines penetrated a mudstone-siltstone breccia with salt as infillings and veins from 114 m (increasing in abundance) to the bottom of the hole at 306 m (Fig. 4-47). Although the main evaporite zone was not intersected in this hole, it is probably present at greater depth.

The overall surficial expression of the Roslin structure is similar to that described in the Canfield Creek area. Outcrops are scattered and scarce, and the strata exposed are disturbed, steeply dipping and often overturned.

GEOPHYSICS

The area in the vicinity of Roslin is included on a Nova Scotia Research Foundation Bouguer anomaly map, at a scale of 4 inches equals 1 mile (Fig. 4-48).

Gravity modelling by Bidgood (1970) on the Roslin Bouguer gravity anomaly indicated a "good fit" using a density contrast of 0.22g/cc for a body 2700 m across extending from 25 m below the ground surface to a depth of 2700 m. A total intensity magnetometer high (Fig. 4-49) coincident with the Bouguer gravity anomaly minimum was thought to be caused by the occurrence of a rather rare mineral rinneite ($FeCl_2.3KCl.NaCl$). This mineral is believed to result from reaction of evaporite bittern with clay minerals (Nova Scotia Research Foundation, 1967a).

A reflection seismograph survey was carried out by Beaver Geophysical Services Limited along Highway 21 which runs diagonally across the Roslin structure (Fig. 4-50). A large up-thrust fault block was inferred with faulting shown in the regions of shot points 203 and 208 (Beaver Geophysical Services Limited, 1965).

GEOCHEMISTRY

Cole (1930a) reported the following analyses of water taken from salt spring No. 8 that bubbles up in the centre of a pond on Plaster Creek near

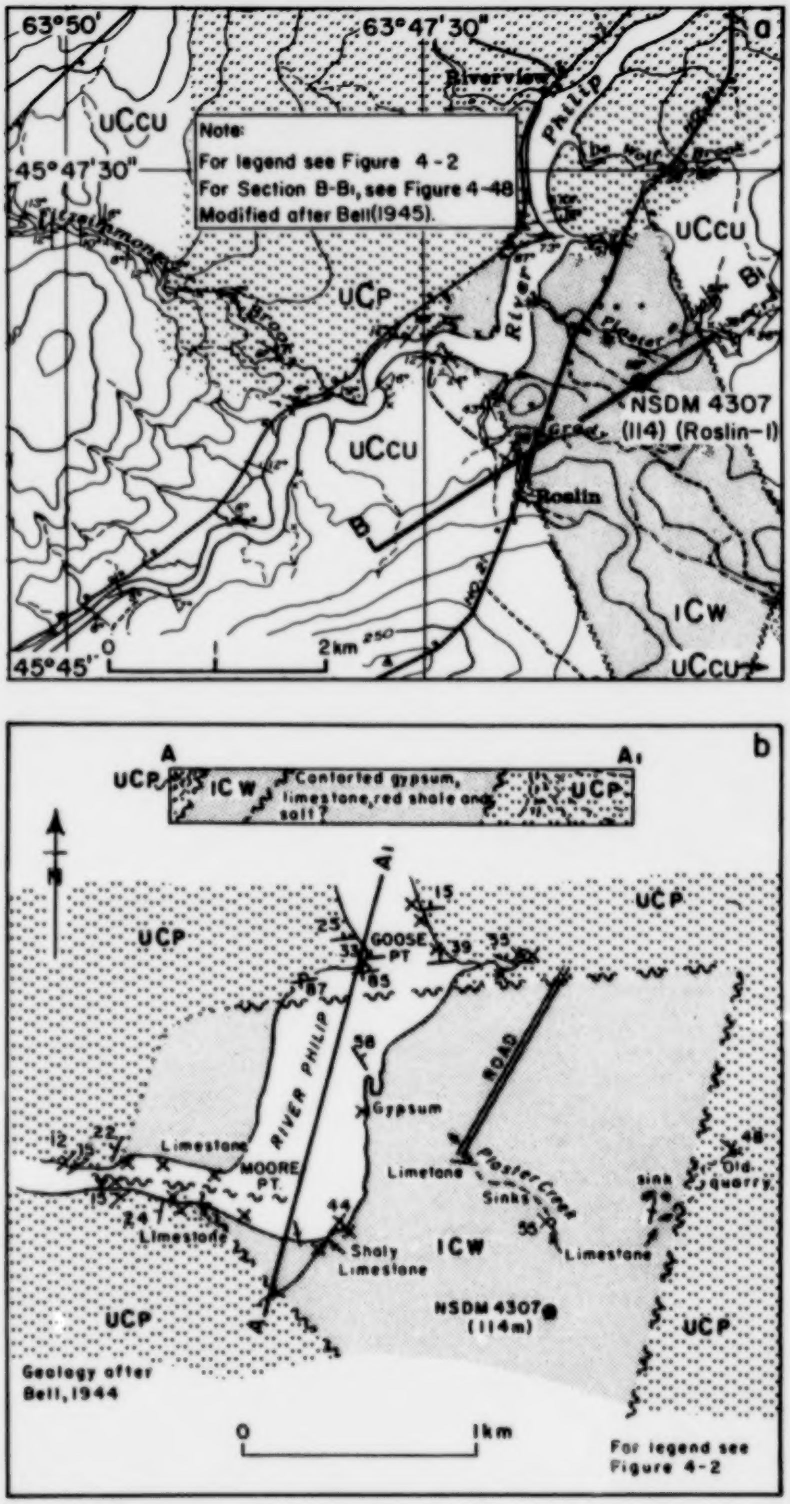

63°50'
63°47'30"
a
Riverview
Philip
uCcu
Note:
For legend see Figure 4-2
For Section B-B1, see Figure 4-48
Modified after Bell(1945).
45°47'30"
Wolf Brook
uCcu
River
B1
uCP
Brook
Plaster
NSDM 4307
(114) (Roslin-1)
uCcu
Roslin
B
lCw
45°45'
0
1
2km
250
uCcu
b
A
A1
uCP
lC w
Contorted gypsum, limestone, red shale and salt?
uCP
N
A1
15
uCP
uCP
25
GOOSE PT
33
39
35
65
67
RIVER PHILIP
58
ROAD
Gypsum
12
22
15
Limestone
MOORE PT.
Limetone
Plaster Creek
48
Old quarry
sink
13
Sinks
24
44
55
Limestone
Shaly Limestone
lCW
Limestone
NSDM 4307
(114m)
A
uCP
uCP
Geology after Bell, 1944
0
1km
For legend see Figure 4-2

Figure 4-46. Geology in the vicinity of the Roslin occurrence, Cumberland County.

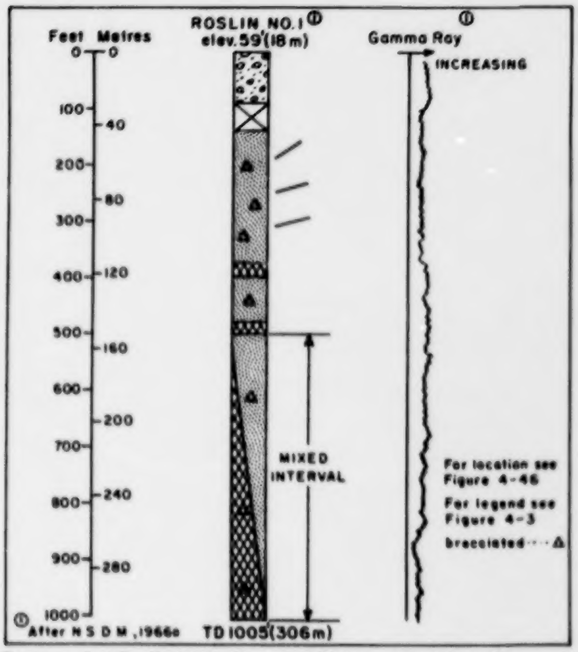

Feet Metres
ROSLIN NO.1 ①
elev.59'(18 m)
① Gamma Ray
INCREASING
0
100
200
300
400
500
600
700
800
900
1000
0
40
80
120
160
200
240
280
MIXED INTERVAL
For location see Figure 4-46
For legend see Figure 4-3
brecciated ··· Δ
① After N S D M ,1966a
TD 1005(306m)

Figure 4-47. Drillhole profile, Roslin No. 1 (NSDM 4307), Roslin occurrence, Cumberland County.

Roslin Post Office (Table 4-13). This composition is typical of moderate $CaSO_4$ rich springs indicative of significant dissolution of gypsum in addition to salt.

ECONOMIC CONSIDERATIONS

The Roslin occurrence consists of impure halite veins in brecciated mudstone and siltstone. The main evaporite section was not penetrated by diamond-drilling, but its presence is suggested by a negative Bouguer gravity anomaly. This structure is apparently fault bound with younger Pictou Group and Cumberland Group rocks. The Windsor Group comprises steeply dipping and locally overturned fossiliferous limestone, calcareous shale, red siltstone, and gypsum. These rocks are similar faunally, lithologically and structurally to those in the Nappan and Pugwash areas. This is considered to be a small, complex diapir with the salt mass occurring at depth. Based upon the available data this occurrence is not considered to be of economic interest.

Table 4-13. Chemical analyses of Roslin Spring, Cumberland County, Nova Scotia.*

Roslin Spring (No. 8)

FIELD NOTES AT TIME OF SAMPLING	
Temperature of atmosphere, °F	78
Temperature of brine, °F	47
Baume degrees	1.0
Equivalent specific gravity ...	1.007
LABORATORY NOTES	
Specific gravity at 60°F	1.008
Total solids at 110°C	1.13
Reaction	None
ANALYSES OF SOLIDS	
Na ....Per cent	25.66
K ....Per cent	0.31
Ca ....Per cent	7.95
Mg ....Per cent	0.21
SO_4 ....Per cent	18.65
Cl ....Per cent	42.30
Br ....Per cent	n.d.
I ....Per cent	n.d.
Totals	95.08
HYPOTHETICAL COMBINATION	
$CaSO_4$ ....Per cent	26.42
$CaCl_2$ ....Per cent	0.49
$MgSO_4$ ....Per cent	-
$MgCl_2$ ....Per cent	0.82
K_2SO_4 ....Per cent	-
KCl ....Per cent	0.59
Na_2SO_4 ....Per cent	-
NaCl ....Per cent	66.77
Total	95.09

*L. H. Cole (Table 1, p. 8, 1930a)

Chemical analyses of Roslin No. 1 are presented in Appendix 2.

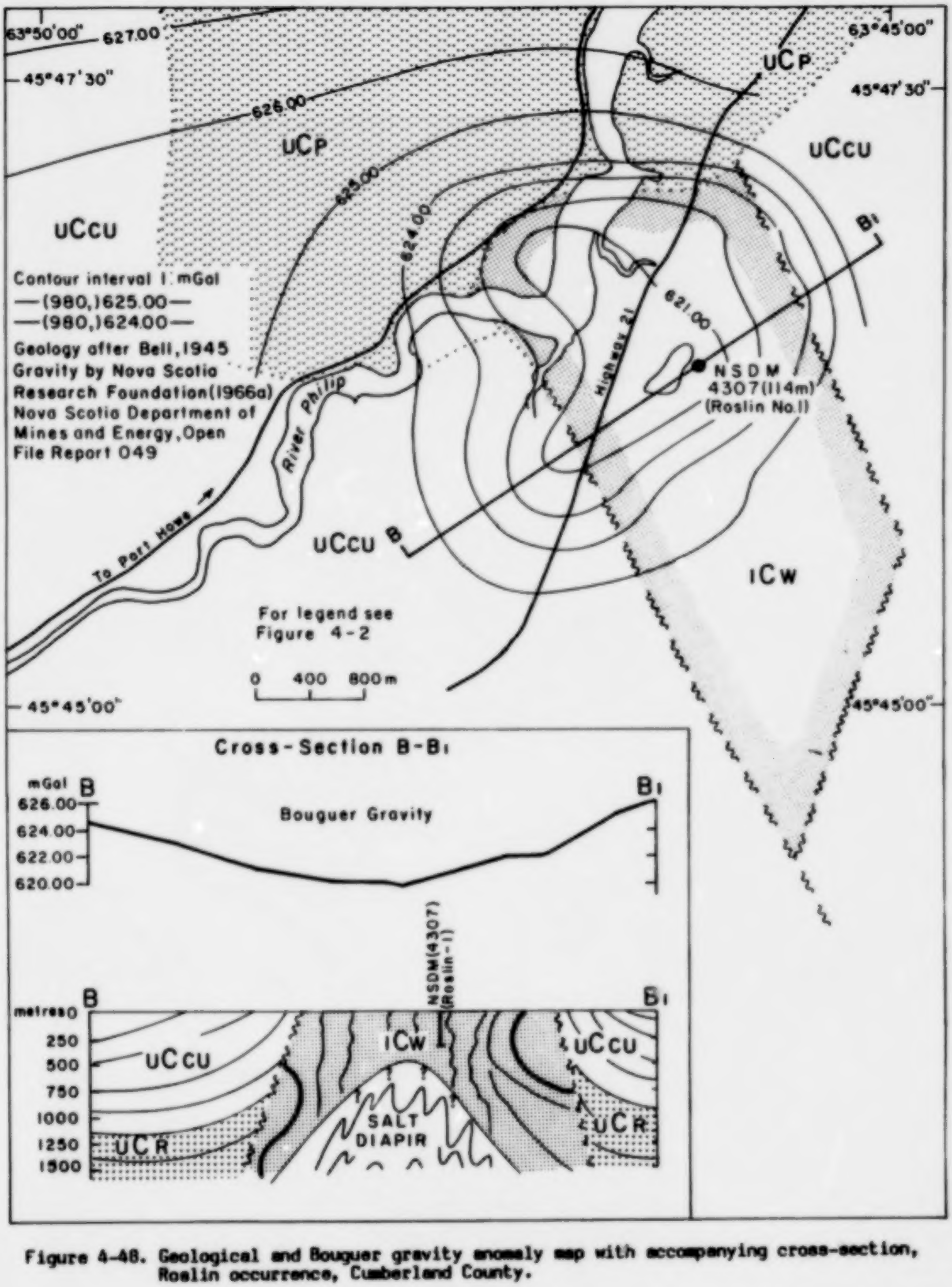
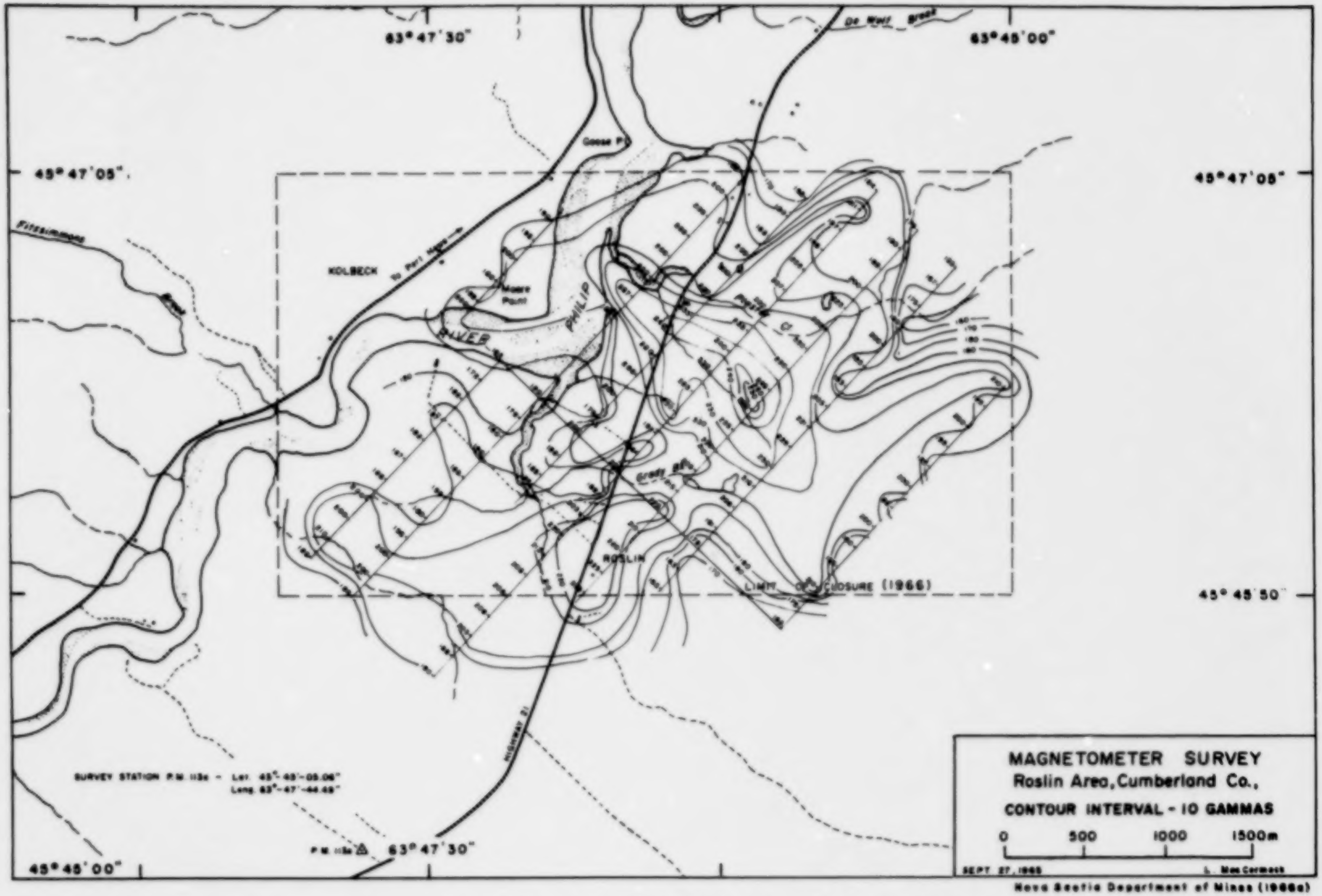
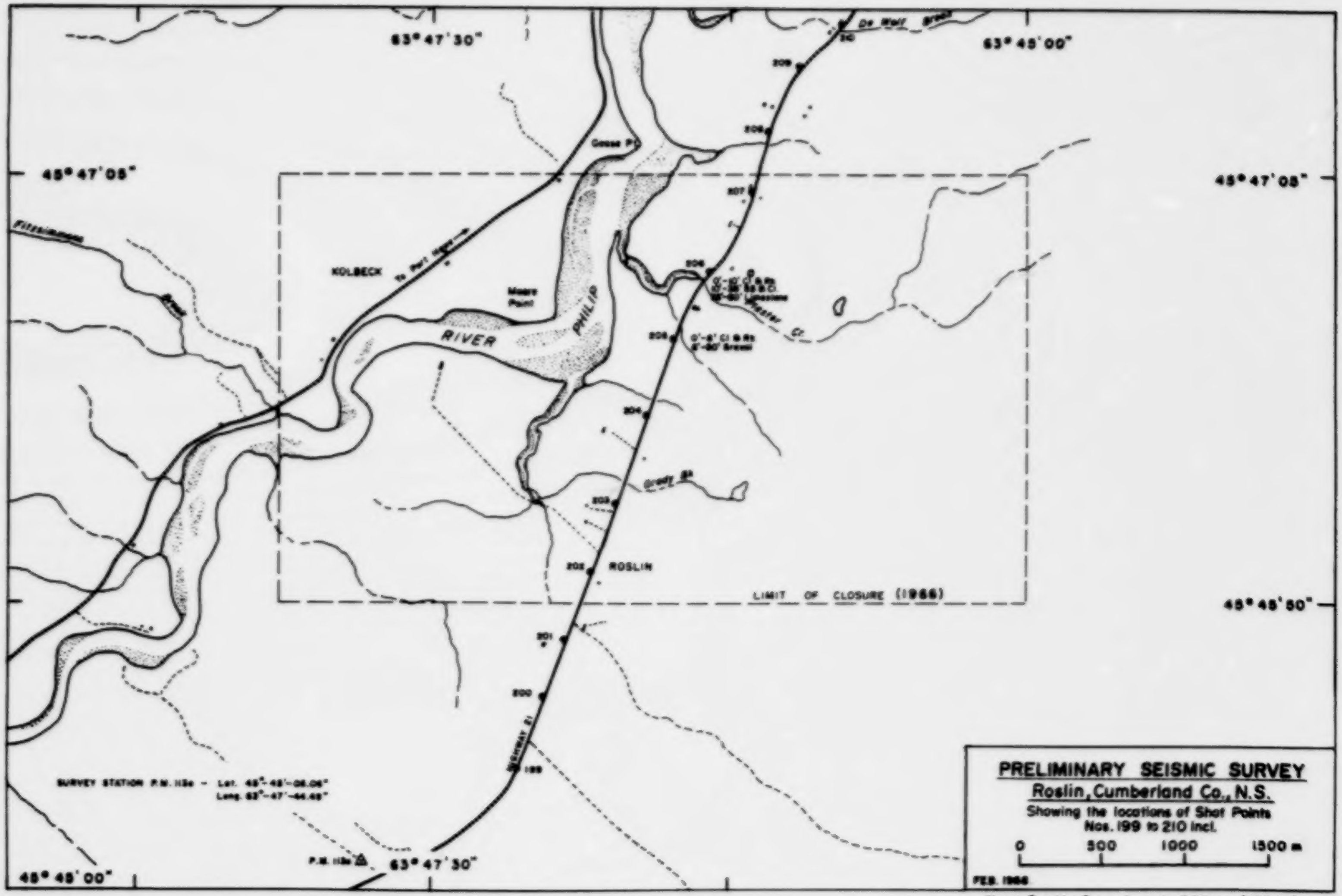

63°50'00"
627.00
45°47'30"
626.00
uCP
uCcu
625.00
624.00
Contour interval 1 mGal
—(980,)625.00—
—(980,)624.00—
Geology after Bell, 1945
Gravity by Nova Scotia Research Foundation(1966a)
Nova Scotia Department of Mines and Energy, Open File Report 049
River Philip
To Port Howe →
uCcu
B
For legend see Figure 4-2
0 400 800m
45°45'00"
uCP
63°45'00"
45°47'30"
uCcu
B1
Highway 2
621.00
NSDM 4307(114m) (Roslin No.1)
lCw
45°45'00"
Cross-Section B-B1
mGal
B
B1
626.00
624.00
622.00
620.00
Bouguer Gravity
NSDM(4307) (Roslin-1)
B
B1
metres 0
250
500
750
1000
1250
1500
uCcu
lCw
uCcu
uCR
SALT DIAPIR
uCR

Figure 4-48. Geological and Bouguer gravity anomaly map with accompanying cross-section, Roslin occurrence, Cumberland County.


63°47'30"
63°45'00"
De Wolf Brook
45°47'05"
45°47'05"
Goose Pt.
Fitzsimmons Brook
KOLBECK
to Port Howe
Money Point
PHILIP
RIVER
Grady Brook
ROSLIN
LIMIT OF CLOSURE (1966)
45°45'50"
HIGHWAY 21
SURVEY STATION P.M. 113a - Lat. 45°-45'-05.06"
Long. 63°-47'-44.45"
P.M. 113a
63°47'30"
45°45'00"
MAGNETOMETER SURVEY
Roslin Area, Cumberland Co.,
CONTOUR INTERVAL - 10 GAMMAS
0
500
1000
1500m
SEPT. 27, 1965
L. MacCormack

Nova Scotia Department of Mines (1966a)

Figure 4-49. Magnetometer survey, Roslin area, Cumberland County.


PRELIMINARY SEISMIC SURVEY
Roslin, Cumberland Co., N.S.
Showing the locations of Shot Points
Nos. 199 to 210 incl.
0
500
1000
1500 m
FEB. 1966
63° 47' 30"
63° 45' 00"
45° 47' 05"
45° 48' 50"
45° 48' 00"
LIMIT OF CLOSURE (1966)
KOLBECK
Moore Point
RIVER
PHILIP
Goose Pt.
ROSLIN
Grady Br.
Chester Cr.
De Wolf Brook
Fitzsimmons Brook
Highway 21
SURVEY STATION P.M. 118a - Lat. 45°-48'-08.08"
Long. 63°-47'-44.48"
P.M. 118a
199
200
201
202
203
204
205
206
207
208
209
210
0'-4' Cl & Rb
4'-60' Gravel

Nova Scotia Department of Mines (1966a)

Figure 4-50. Preliminary seismic survey shot points location map, Roslin occurrence, Cumberland County.

CHAPTER V
PICTOU AREA

INTRODUCTION

The Pictou area is located in Pictou County and includes the Windsor Group outcrop areas near Eureka and Knoydart (Figs. 1-4 and 1-10).

Salt has not been established by drilling in the Pictou area, however, several localities of salt springs have been described by previous workers including Haliburton (1829), How (1869), Hayes (1931) and Cole (1930a). Although the salt springs in the area indicate the presence of salt, the springs are associated with major faults which probably act as access channels for the dissolution of deep salt. Bouguer gravity anomalies indicative of salt are not apparent in the area. Major deep drilling is confined to the Upper Carboniferous coal basins. Exploration potential for salt in this area appears to be very limited.

DUNMAGLASS-KNOYDART

The Dunmaglass area is located approximately 30 km northeast of Sutherlands River and 20 km northwest of Antigonish on the Northumberland Strait shore, western Antigonish County (Figs. 5-1 and 1-10). This area was explored for a potential salt source by a private concern in 1919. Three diamond-drill holes were sunk for the Maple Mountain Salt Mining Company by the Nova Scotia Department of Mines. These holes were drilled to test the source of salt springs and seeps located near Dunmaglass Brook. Descriptions of the drilling results from the Nova Scotia Department of Mines, Annual Report on the Mines (1920), are summarized below:

Borehole No. 1 (D-1, Fig. 5-1), located 18.3 m (60 ft.) east of Dunmaglass Brook, 50.3 m (165 ft.) southwest of the main road, and 311 m (1020 ft.) north of the bridge over Dunmaglass Brook, was stopped at 39.6 m (130 ft.) in "hard brown limestone."

Borehole No. 2 (D-2, Fig.5-1), located 55.5 m (182 ft.) east of the bridge over Dunmaglass Brook, was stopped in "igneous formation", at a depth of 32.1 m (105 ft. 3 in.).

Borehole No. 3 (D-3, Fig. 5-1), located 122 m (400 ft.) northwest of borehole No. 2, was stopped at a depth of 25.9 m (85 ft. 2 in.).

A fourth hole, borehole No. 4 (D-4, Fig. 5-1), was drilled in 1920 (Nova Scotia Department of Mines, Annual Report on Mines, 1921), 289.6 m (950 ft.) north of borehole No. 1, midway between Martin Road and Brook. The hole intersected sandstone and shale with "igneous" rocks to 128 m (420 ft.) and sandstone, shale and limestone to the bottom of the hole at 195.1 m (640 ft.).

Salt was not reported to have been intersected or indicated in any of the drilling and the source for the salt springs and seeps was not located. These holes were apparently drilled in rocks mapped as Lower Devonian, Knoydart Formation by Benson (1974).

The Dunmaglass-Knoydart area was investigated for its potash and salt potential by Pohl as part of a regional study by Hayes (1931). Previous workers who have described the geology in the area include Fletcher (1887), Williams (1914), Bell (1926), Benson (1974) and Boucot et al. (1974). The geology outlined in the following paragraphs is based on mapping by Benson (1974) (Fig. 5-1).

The oldest rocks in the area are located east of Dunmaglass, in the Antigonish Highlands. These rocks were mapped as Browns Mountain Group and were assigned to the Cambro-Ordovician, but are now considered to be Hadrynian-Cambrian by Murphy et al. (1980). A major fault with a north-northeastward trend named the Hollow Fault separates a block of Middle Paleozoic (Silurian-Devonian) sedimentary and volcanic strata on the northwest from the older Browns Mountain Group rocks on the southeast.

To the north of Dunmaglass, the Silurian and Devonian rocks occur in a southwesterly plunging syncline whose southeastern limb is complicated by folding adjacent to the Hollow Fault and whose northwestern limb is apparently overturned (in part).

The Devonian strata occur primarily in the area southwest of McAras Brook as a wedge bound on the southeast by the Hollow Fault, on the northwest by onlapping Carboniferous strata, and pinch out abruptly on the southwest near Bailey Brook. The Carboniferous onlap is defined between Bailey Brook and near McAras Brook where rocks assigned to the Horton, Windsor and Canso Groups are indicated by Benson (1974). Keppie et al. (1978) reinterpreted the Knoydart Point-Moydart Point Carboniferous shore section because of spore ages from the Carboniferous sediments present. The intercalated volcanic and conglomerate sandstone section at the base of the section rests with angular unconformity on the Knoydart Formation. These volcanics were considered by Benson (1974) to be part of the Lower Carboniferous Horton Group, but were assigned by Keppie et al. (1978) to an unnamed group containing rocks of Late Devonian age. In addition, the stratified sandstone and conglomerate section above the volcanic flows (mapped as Rights River Formation of the Horton Group) is now considered to be Upper Windsor based on spore assemblage. A single Upper Windsor (D Subzone?) limestone outcrops on the shore and is overlain with transitional contact by strata assigned to the Upper Windsor and Canso Groups. The Canso-Windsor contact is not identifiable by marked lithologic change and is located somewhat arbitrarily. In the vicinity of Ardness the Windsor Group is indicated to onlap the Devonian Knoydart Formation and is in turn onlapped by the Canso Group.

The presence of evaporites in the Windsor Group in this area has not been indicated by previous workers. The local stratigraphy suggests an Upper Windsor nonevaporitic facies. Evaporities are common in the Lower Windsor in other areas and may onlap in the area to the west and north of this section, beneath the Northumberland Strait. HB Fina F-25, in the Northumberland Strait 50 km north-northeast of

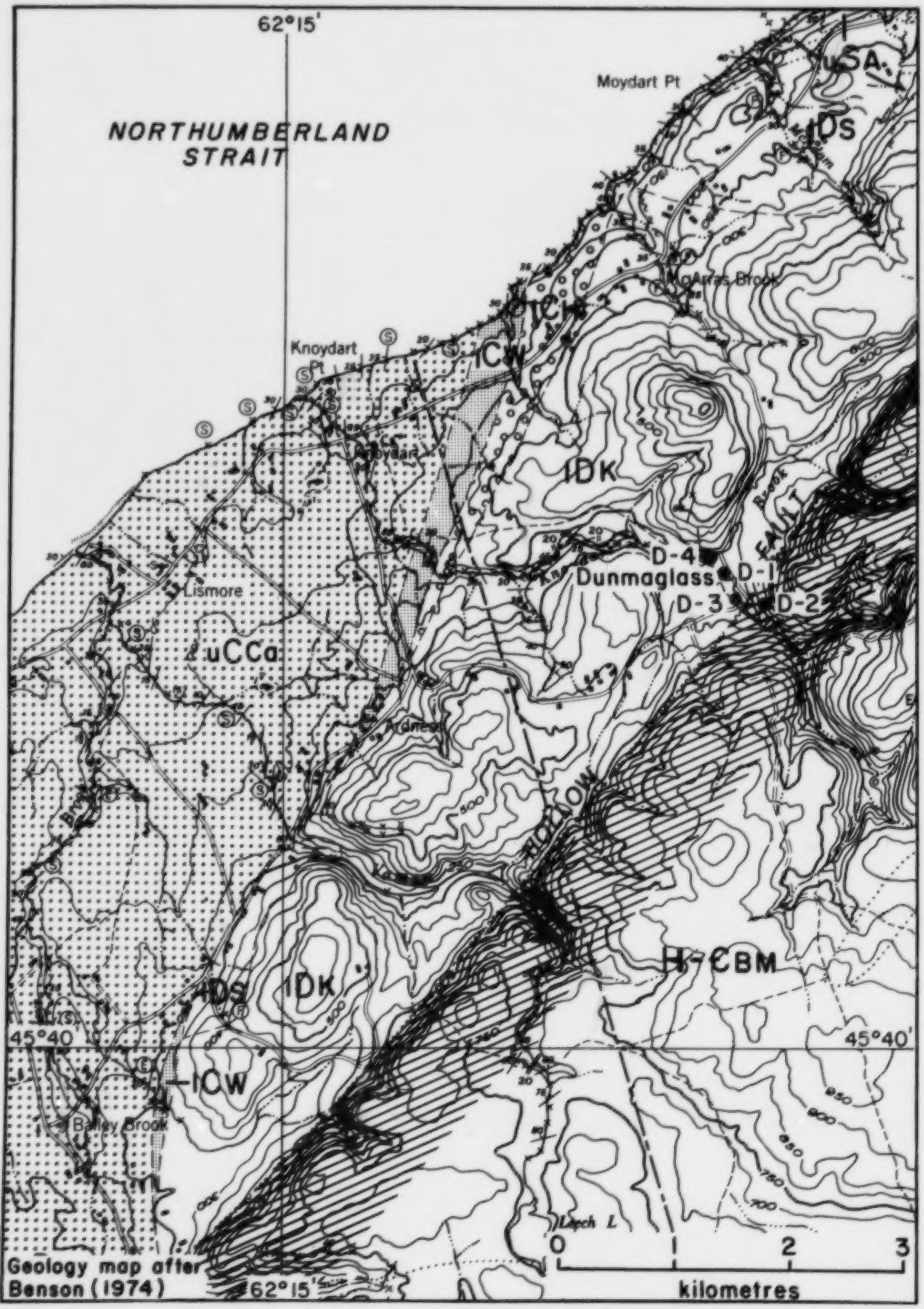

62°15'
NORTHUMBERLAND STRAIT
Moydart Pt
uSA
lDS
MacAras Brook
lCH
lCW
Knoydart Pt
Moydart
lDK
D-4
Dunmaglass
D-1
D-3
D-2
FAULT
Lismore
uCCa
Ardness
HOLLOW
H-€BM
lDS
lDK
45°40'
45°40'
lCW
Bailey Brook
Loch L
0
1
2
3
kilometres
Geology map after Benson (1974)
62°15'
500
750
700
650
600

Figure 5-1. Geological map, Dunmaglass, Antigonish County.

LEGEND

UPPER CARBONIFEROUS

UCS	STELLARTON (PICTOU) GROUP Siltstone and sandstone
UCCU-P	CUMBERLAND and/or PICTOU GROUP(S) Sandstone, conglomerate and siltstone
UCCU	CUMBERLAND GROUP Undivided
UCR	RIVERSDALE GROUP Shale, sandstone and conglomerate
UCCa	CANSO GROUP Sandstone and siltstone

LOWER CARBONIFEROUS

lCW	WINDSOR GROUP Sandstone, siltstone, limestone, gypsum and salt?
lCH	HORTON GROUP Sandstone and conglomerate

LOWER DEVONIAN

lDK	*KNOYDART FORMATION;* mudstone, siltstone and sandstone
lDS	*STONEHOUSE FORMATION;* sandstone and siltstone

UPPER SILURIAN

USA	ARISAIG GROUP Shale, siltstone and sandstone

HADRYNIAN-CAMBRIAN

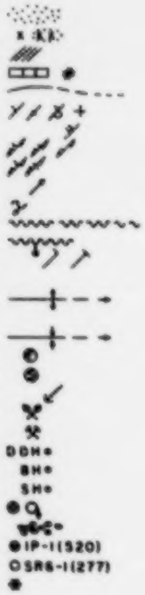
H-CBM	BROWNS MOUNTAIN GROUP Metasedimentary and volcanic rocks

HADRYNIAN

Hu	Undivided granitoid and metamorphic rocks

SYMBOLS

Heavily drift-covered area ....
Rock outcrop, area of outcrop ....
Limestone or dolomite outcrop (Faribault-Fletcher maps) ....
Gypsum outcrop ....
Geological boundary (defined, approximate, assumed) ....
Bedding, tops known (inclined, vertical, overturned, horizontal) .
Bedding, tops unknown (inclined) ....
Schistosity (inclined, vertical, dip unknown) ....
Gneissosity (inclined, vertical) ....
Plunge of minor fold ....
Drag fold (arrow indicates plunge) ....
Fault (defined, approximate, assumed) ....
Fault (solid circle indicates downthrow side) ....
Joint (inclined, vertical) ....
Anticline (defined, approximate, arrow indicates direction of plunge) ....
Syncline (defined, approximate, arrow indicates direction of plunge) ....
Fossil locality ....
Spore sample ....
Glacial striae (ice flow direction known) ....
Gravel deposit ....
Quarry ....
Diamond-drill hole ....
Borehole ....
Sinkhole ....
Salt spring ....
Observed karst topography ....
Drillhole intersecting salt; number (depth to salt, metres) ......
Drillhole without salt; number (Total depth, metres) ....
Drillhole location precise to 150 m ....



MINERALS

Anhydrite	ah	Limestone	lst
Gypsum	gyp	Pyrite	py
Lead	Pb	Zinc	Zn
Celestite	Sr		

McAras Brook (Fig. 5-2), intersected a typical thick section of Lower Windsor salt underlain by anhydrite, thin basal limestone and Horton Group rocks (Keppie et al., 1978).

The Windsor Group in the Dunmaglass area appears to be representative of a marginal clastic facies and is not considered to have good potential for salt.

The depositional environments and lithologies described by Boucot et al. (1974) and others for the Silurian and Devonian rocks in the area are not indicative of evaporitic depositional conditions. A local facies variation containing salt is conceivable but not probable in the area. The salt springs and seeps reported to occur in the Dunmaglass area were not located by Hayes (1931) or other investigators. The drilling by Maple Mountain Salt Mining Company did not locate the source of the brines.

The origin of these brines is problematic. Rock salt has never been reported in the Devonian or older rocks which underlie the area where the springs are reported. The nearest Windsor Group rocks mapped at the surface are nonsaline facies and occur 4 km to the northwest. Salt is known to occur beneath the Gulf of St. Lawrence (Fig. 5-2), but a connection with the pre-Carboniferous basement rocks at Dunmaglass would involve major faulting and migration of saline water.

KEMPTOWN

The geology in the vicinity of Kemptown (Figs. 1-10 and 5-3) was described and mapped by Stevenson (1958). The geology in this area is dominated by several east-west trending faults including the Cobequid, North River and Riversdale Faults which are part of the Glooscap Fault System (Minas Geofracture). These Faults define, at the surface, fault slices of Upper Carboniferous strata comprising Canso, Riversdale and Pictou and/or Cumberland Groups. These fault blocks have been moderately to strongly folded and the section of Riversdale strata exposed on the Salmon River is partially overturned.

Cole (1930a) reported that "Approximately one mile true south of Kemptown, Colchester County, a series of seepages occurs coming out of the steeply dipping rocks on the east bank of a small creek. These seepages have no appreciable flow but are distinctly saline to taste."

Brine from the spring was analyzed by Cole (1930a), and the results are presented in Table 5-1. This spring has a significant quantity of Na_2SO_4 which is not characteristic of a Windsor Group source.

Cole's (1930a) description of the salt spring location places it very close to the North River Fault (Fig. 5-3) that marks the contact between Cumberland and/or Pictou Groups strata to the north and Riversdale Group strata to the south. In this situation the salt of the Windsor Group probably occurs at a depth of more than 1000 m. The brines, if originating from the Windsor Group, are probably migrating upwards along the permeable fracture system developed adjacent to the Fault. Alternatively they may represent formation waters migrating from and through permeable strata of Late Carboniferous age.

Table 5-1. Chemical analyses of Kemptown salt spring*

Sample No		**29**
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere, °F		75
Temperature of brine, °F		57
Baume degrees		2.5
Equivalent specific gravity		1.016
LABORATORY NOTES		
Specific gravity at 60°F		1.02141
Total solids at 110° C		2.88
Reaction		N
ANALYSES OF SOLIDS		
Na	Per cent	36.62
K	Per cent	0.27
Ca	Per cent	1.09
Mg	Per cent	0.10
SO_4	Per cent	5.90
Cl	Per cent	54.58
Br	Per cent	none
I	Per cent	none
Totals		98.56
HYPOTHETICAL COMBINATION		
$CaSO_4$	Per cent	3.71
$CaCl_2$	Per cent	-
$MgSO_4$	Per cent	0.50
$MgCl_2$	Per cent	-
K_2SO_4	Per cent	0.60
KCl	Per cent	-
Na_2SO_4	Per cent	3.77
NaCl	Per cent	89.98
Totals		98.56

*Cole (1930a)

Windsor Group rocks do not outcrop in the immediate area of Kemptown, but do occur associated with Horton Group rocks in several small fault blocks approximately 10 km to the southwest.

BRIDGEVILLE

Bridgeville is located approximately 15 km south of Stellarton (Fig. 1-4). The geology in this area (Figs. 5-4 and 1-10) was mapped and reported by Benson (1967) and Giles (1982). Fletcher (1892) reported that "At Bridgeville a salt spring issues from beneath a cliff of gypsum ..." This spring has not been located or described by subsequent workers.

Benson (1967) indicated an outcrop band of gypsum along the eastern contact with pre-Carboniferous rocks. Giles (1982) indicated that this gypsum unit (Bridgeville Formation) is underlain by a locally fossiliferous marine limestone unit (Holmes Brook Formation) which rests with angular unconformity on older pre-Carboniferous (Silurian) rocks (Fig. 5-4). This limestone unit is believed to be correlative with the Gays River Formation. A thick section of sandstone with interbeds of limestone (Forbes

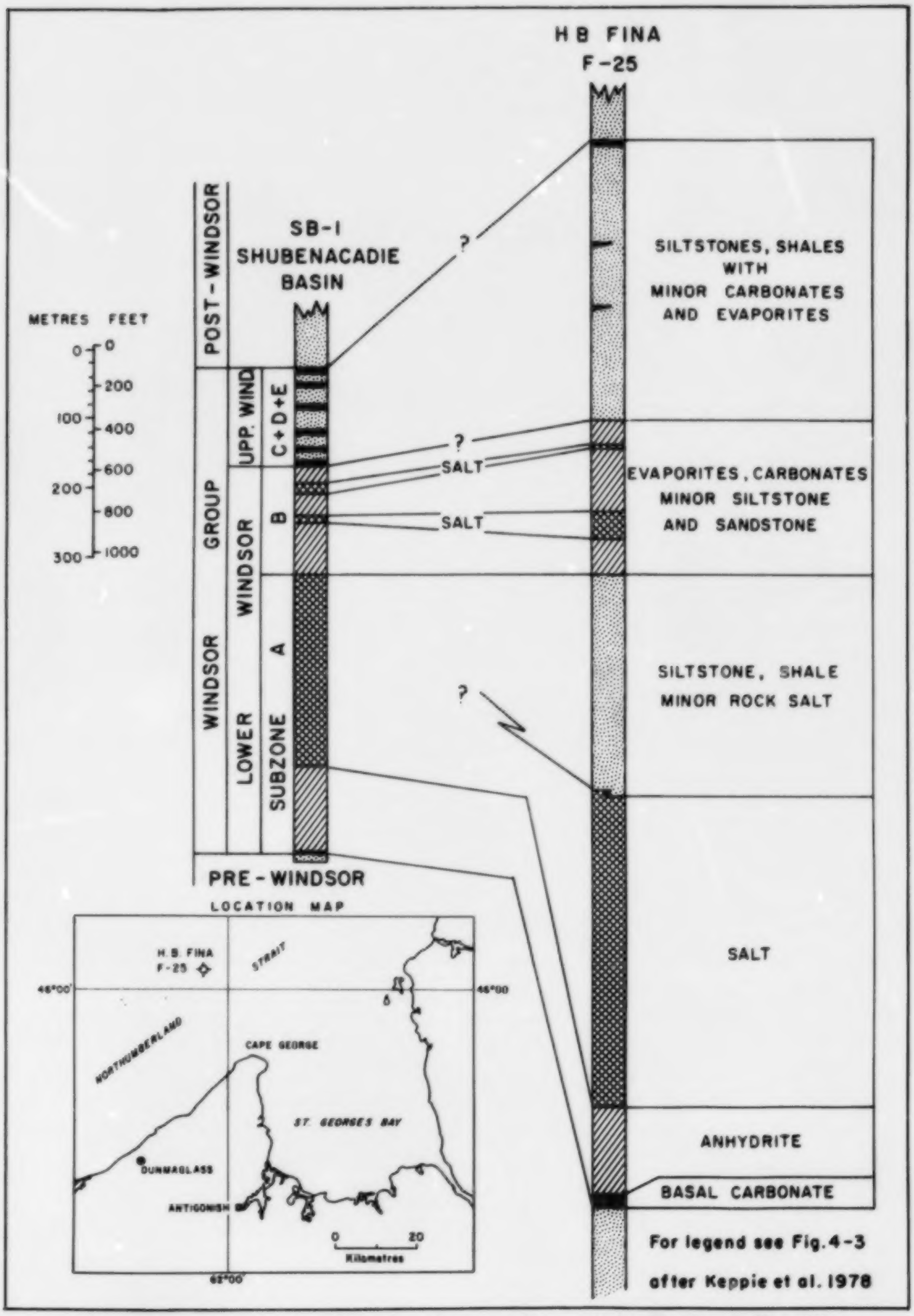

HB FINA
F-25
SB-1
SHUBENACADIE
BASIN
METRES FEET
0
100
200
300
0
200
400
600
800
1000
POST-WINDSOR
WINDSOR GROUP
UPP. WIND
C+D+E
LOWER WINDSOR
SUBZONE A
B
PRE-WINDSOR
?
SALT
SALT
SILTSTONES, SHALES WITH MINOR CARBONATES AND EVAPORITES
EVAPORITES, CARBONATES MINOR SILTSTONE AND SANDSTONE
SILTSTONE, SHALE MINOR ROCK SALT
SALT
ANHYDRITE
BASAL CARBONATE
LOCATION MAP
H.B. FINA F-25
STRAIT
NORTHUMBERLAND
46°00'
CAPE GEORGE
ST. GEORGES BAY
DUNMAGLASS
ANTIGONISH
0 20
Kilometres
62°00'
For legend see Fig.4-3
after Keppie et al. 1978

Figure 5-2. Correlation of Windsor Group strata in hole HB Fina F-25, with the Windsor Group of the Shubenacadie Basin.

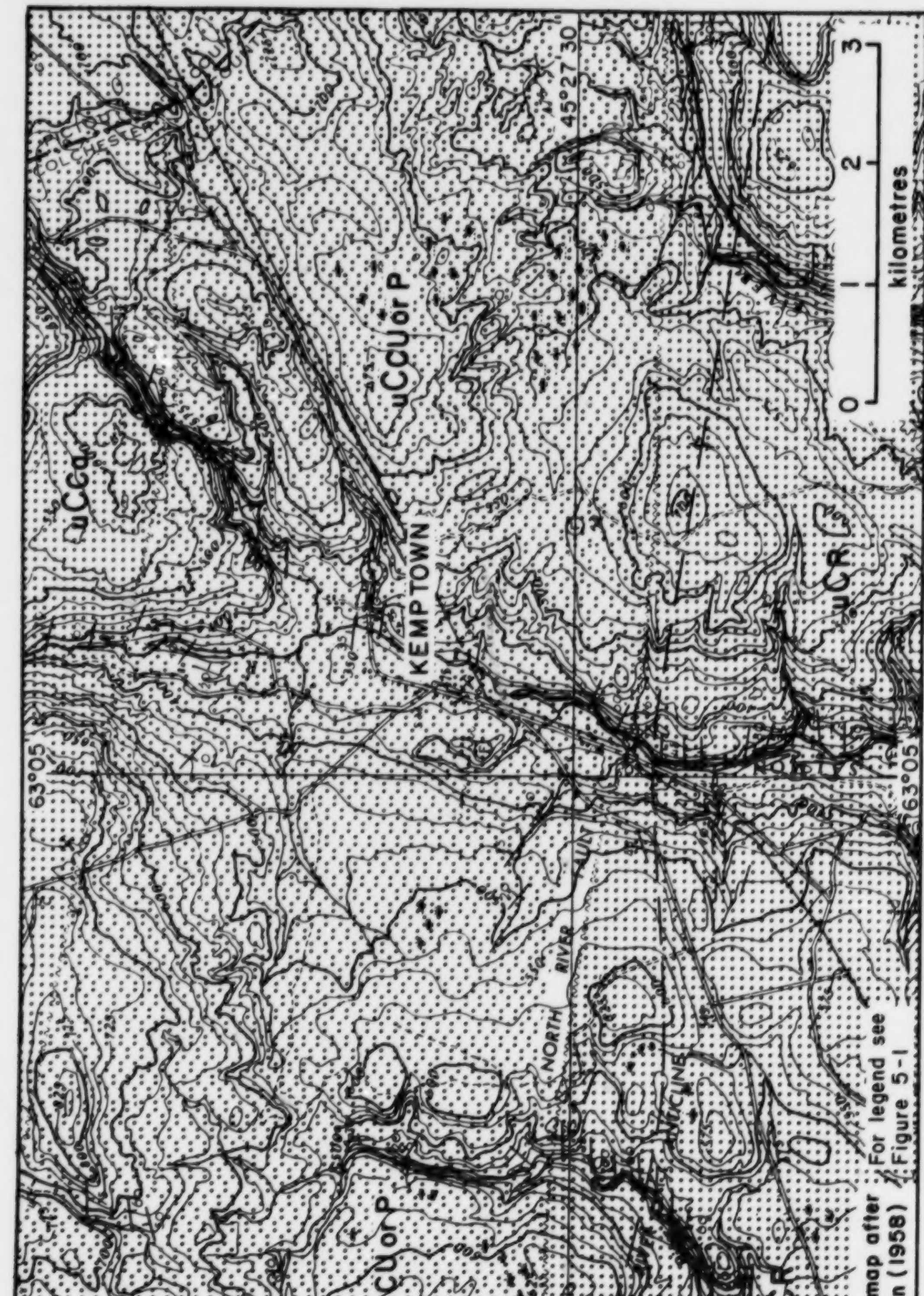

uCCa
uCCU or P
KEMPTOWN
uCR
uCCU or P
uCR
COLCHESTER
NORTH RIVER
NORTH
63°05'
63°05'
45°27'30"
45°27'30"
0
1
2
3
kilometres
Geology map after Stevenson (1958)
For legend see Figure 5-1

Figure 5-3. Geological map, Kemptown area, Colchester County.

Lake and Churchville Formations) overlies this gypsum and basal limestone section. This section is in turn overlain by Canso Group strata. The Canso-Windsor contact was mapped and described as conformable by Benson (1967) although Giles (1982) indicated local faulted contacts. The southern border of the area is marked by the Chedabucto Fault. According to Giles (1982) this is a complex fault zone that contains many subsidiary faults. This fault zone narrows to the east where the Windsor Group is apparently cut off.

The main salt horizon in the Windsor Group, in most instances, is located above a basal sulphate unit. If this stratigraphic sequence applies in this area the salt should occur above the Bridgeville Formation sulphate and beneath the sandstone and limestone section of the Forbes Lake and Churchville Formations. Giles (1982) indicated an unconformity at this contact. Deep drilling in this area is very rare. In 1978 deep drilling near East River at a location 2.5 km southeast of Eureka (Fig. 5-4) by the Nova Scotia Department of Mines and Energy (1979) and Chevron Canada Ltd. indicated salt is not present in the Windsor Group section at this locality (P. S. Giles, personal communication, 1979). The possibility of occurrence of significant salt deposits in this area is not considered to be favourable.

SALT SPRINGS, PICTOU COUNTY

Salt Springs, Pictou County, is situated approximately 20 km west of Stellarton. The springs from which the community gets its name attracted early interest in possible salt development. The Salt Springs area was the site of the earliest attempt to manufacture salt in Nova Scotia. Cole (1930a) reported that in 1813 a shaft 200 feet deep was sunk in an attempt to locate the source of salt springs and seeps abundant in the area. The brine source was not found. A few years later a small amount of salt was produced by evaporating the brine, but this too was soon abandoned. How (1869) (Table 5-2) first described the salt springs in the area and reported the following analyses.

Table 5-2. Analyses of the salt springs in the Salt Springs area.*

	Grains per Imp. Gal.**
Carbonate of lime	3.775
Carbonate of magnesia	2.932
Carbonate of iron	0.181
Silica	0.560
Sulphate of lime	154.730
Chloride of magnesium	27.330
Chloride of calcium	51.910
Phosphoric acid, boracic acid	-
Bromine, and organic matter	-
Undetermined common salt	4133.500
Total	4374.917
Specific gravity at 53°F	1.04669

*How (1869)

**1 grain/Imp. gal. = 0.01425 gm/l

Cole (1930a) described a salt spring (No. 28) in the area as follows, "On the west bank of West River, to the south of Salt Springs, Pictou County, a series of small springs or seepages occurs just above the river level. These springs are on the farm of D. M. McKay. No appreciable flow is present". This spring is apparently the same as the one described by How (1869) and analyzed by Cole (1930a) (Table 5-3). The major dissolved consituent of the salt spring is NaCl, but it contains minor $CaCl_2$ and $CaSO_4$.

Table 5-3. Analyses of the spring in Salt Springs, Pictou County*.

Sample No.		**28**
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere, °F		75
Temperature of brine, °F		n.d.
Baume degrees		5.5
Equivalent specific gravity		1.037
LABORATORY NOTES		
Specific gravity at 60°F		1.0425
Total solids at 110°C		5.86
Reaction		N
ANALYSES OF SOLIDS		
Na	Per cent	35.08
K	Per cent	0.30
Ca	Per cent	2.14
Mg	Per cent	0.14
SO_4	Per cent	1.77
Cl	Per cent	57.60
Br	Per cent	none
I	Per cent	none
Totals		97.03
HYPOTHETICAL COMBINATION		
$CaSO_4$	Per cent	2.50
$CaCl_2$	Per cent	3.96
$MgSO_4$	Per cent	-
$MgCl_2$	Per cent	0.54
K_2SO_4	Per cent	-
KCl	Per cent	0.57
Na_2SO_4	Per cent	-
NaCl	Per cent	89.47
Totals		97.04

*Cole (1930a)

The geology in the vicinity of Salt Springs was described and mapped by Faribault and Fletcher (1902). The geology of the area was also described and mapped by Gillis (1964) as part of the northwestern Pictou County area. Windsor Group rocks outcrop sparingly in the area and are apparently only exposed near Limerock, 4 km east of Salt Springs. Murray (1975) reported the occurrence of high-calcium limestone in the vicinity of Limerock. Four shallow diamond-drill holes were drilled by the Nova Scotia Department of Mines to test the quality and extent of the limestone. Locations and logs of these holes may be found in Murray (1975). P. S. Giles (personal communication, 1979) considered the limestone unit present to be part of the Upper Windsor C Subzone.

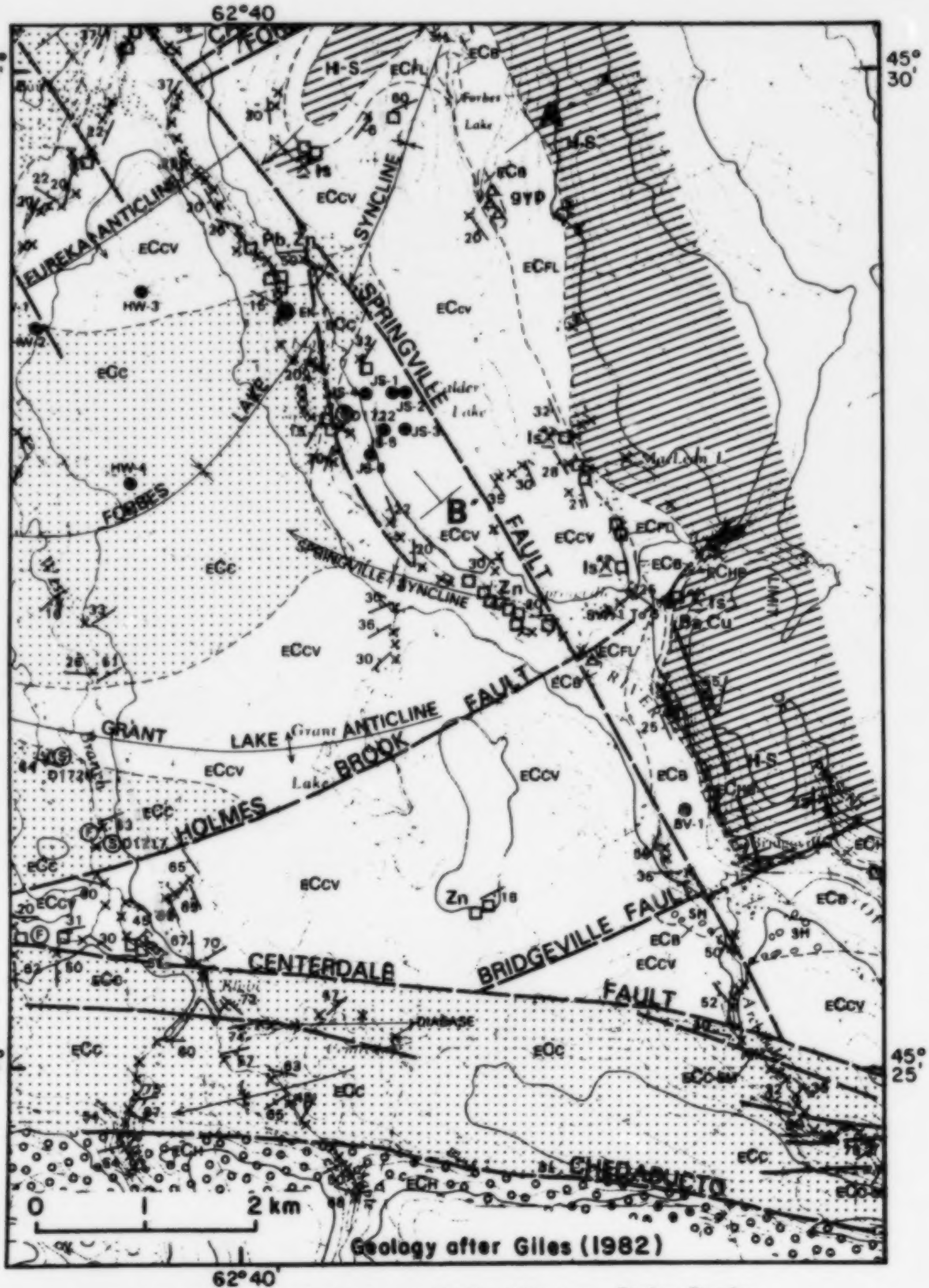
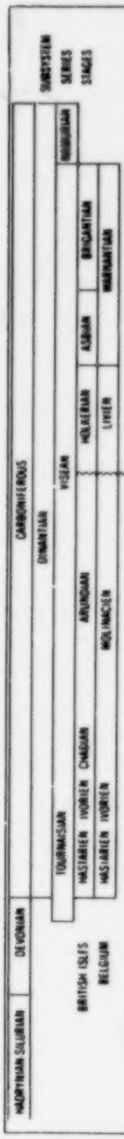

62°40
45° 30'
45° 30'
45° 25'
45° 25'
62°40'
EUREKA ANTICLINE
SYNCLINE
SPRINGVILLE FAULT
LAKE
FORBES
SPRINGVILLE SYNCLINE
GRANT LAKE ANTICLINE
HOLMES BROOK FAULT
CENTERDALE FAULT
BRIDGEVILLE FAULT
CHEDABUCTO
H-S
ECFL
ECB
ECCV
ECC
ECCB
ECH
ECHB
gyp
ls
Pb, Zn
Zn
Ba, Cu
HW-3
HW-4
EK-1
JS-1
JS-2
JS-3
BV-1
B'
DIABASE
Forbes Lake
Calder Lake
Grant Lake
0 1 2 km
Geology after Giles (1982)

Figure 5-4. Geological map, Bridgeville area, Pictou County.

LEGEND



CANSO GROUP

εCc reddish-brown sandstone and shale (εCc) with intercalated grey banded shale and mudstone (εCc-SM); probable equivalent of the Hastings Formation in the Antigonish area

WINDSOR GROUP

εCcv *CHURCHVILLE FORMATION* sandstone, shale and mudstone in numerous small-scale fining-upward cycles, typically reddish-brown to maroon in colour; intercalated sheets of limestone and associated grey fossiliferous mudstone and shale characteristic and assigned member status: (MQ) MacLean Quarry Member, (MB) McLellan Brook Member, (WB) West Branch Member, (EB) East Branch Member, (I) Island Member

εCFL *FORBES LAKE FORMATION* shale, mudstone and paraconglomerate with minor limestone; maroon to pale greyish-red colour is typical; (FL-C) conglomerate and sandstone, restricted to the McLellan Brook area (stippled pattern) and considered a proximal facies of the formation, and (FL-S) Sunnybrae Member (oolitic and algal limestone)

disconformity, possible regional unconformity

εCa *BRIDGEVILLE FORMATION* gypsum and anhydrite, smokey grey-brown in colour, finely crystalline, in part thinly interbedded with limestone and dolostone

εCHB *HOLMES BROOK FORMATION* limestone, less commonly dolostone, in part laminated, peloidal and oolitic, thinly stratified; varies to thickly-bedded or massive algal-bound limestone, sparsely fossiliferous, becoming argillaceous and more thinly bedded towards the top; the formation lies with angular unconformity upon pre-Carboniferous rocks

HORTON GROUP

εCH undivided; medium to dark grey shale, siltstone and fine-grained sandstone; noted in the map area only south of the Chedabucto Fault

Du undivided; mainly pale reddish-brown conglomerate with associated felsic tuff in the Stewart Brook — McLellan Brook area, and mafic volcanic flows in the McGregor Mountain area; possibly equivalent in part to the McAras Brook and/or Fisset Brook Formations

H-S undivided; mainly grey sparsely fossiliferous and bioturbated siltstones of Silurian age; includes mafic volcanic rocks of possible Hadrynian age in the upper reaches of Stewart Brook and coarsely pyroclastic volcanic rocks of unknown age in the bed of McLellan Brook near Kirkmont; unit includes volcanic and sedimentary rocks of possible Ordovician age in the Black Rock — Sunnybrae area

SYMBOLS

Rock outcrop limestone, dolostone, commonly fossiliferous	□
gypsum, anhydrite	△
terrigenous sedimentary rocks	×
volcanic rocks	V
Bedding, horizontal, inclined, vertical, overturned, tops unknown	+ / / / /
Geological boundary, approximate	- - - - -
Fault, approximate	——— ———
Anticline and syncline	✛ ✛
Fossil locality cited in text	Ⓕ
Spore locality, GSC Number	Ⓢ D1715
Diamond-drill hole	●
Principal reference section	●
Water-well used to locate geological boundary	⌖
Sink-hole in gypsum	SH
Mine or quarry; abandoned ls-limestone	△ls
Mineral prospect: Pb-lead, Zn-zinc, Ba-barite, gyp-gypsum, Cu-Copper	Pb,Zn,Ba,gyp,Cu

In 1974 Imperial Oil Limited drilled several deeper diamond-drill holes at Limerock exploring for base metal deposits. Although salt was not encountered in this drilling, drillhole ILR-3 intersected a very steeply dipping (60-80°) section of sandstone and conglomerate to a total depth of 142.3 m (467 ft.) indicating a disturbed section. A steeply dipping fossiliferous limestone unit was reported near the top of the hole, but recovery was poor. The precise relationship of the limestone to the section it overlies and to the section intersected in the Nova Scotia Department of Mines drilling is uncertain. The Windsor Group at this locality occurs as a small fault slice between Canso Group strata to the south and Boss Point Formation to the north. The major West River Fault that passes through the area is part of the Glooscap Fault System. The Salt Springs area is located adjacent to this Fault and it is probable that the salt springs reported in the area are the result of brines derived from Windsor Group salt at depth or are formation water. These brines probably have migrated up permeable fracture zones related to the faulting and possibly through permeable Carboniferous strata. Based upon the available data, the area is not considered to be promising for economic salt deposits.

CHAPTER 6
ANTIGONISH-MABOU AREA

INTRODUCTION

The Antigonish-Mabou area is located in parts of Antigonish and southwestern Inverness Counties in mainland Nova Scotia and Cape Breton Island (Figs. 1-4 and 1-10). Four salt deposits and two occurrences are located in the Antigonish-Mabou area (Fig. 1-4). The deposits are, for the most part, poorly documented as to their quality and lateral extent. They are generally known only from a few drillholes and geophysical data, especially Bouguer gravity anomaly interpretations.

Three deposits located in the Antigonish area are the Antigonish, James River and Southside Harbour deposits. The Antigonish deposit is defined by two drillholes KEH-1 and AP-2-74. The James River deposit is defined by three drillholes KEH-5, JR-3 and AP-1-74. The Antigonish and James River deposits were defined as the result of exploration by Kenneco Exploration (Canada) Limited, Amax Exploration Limited and Hillmor-Rodgers Quebec Uranium et al. between 1966 and 1974. Small shows of potash minerals are reported in the James River deposit. The Southside Harbour deposit is the best defined of the three. It is known from five drillholes: NSDM 1708, NSDM 1835, NSDM 1836, NSDM 4862 (Novasel No. 1) and Brador Oil Southside Harbour No. 1. Traces of potash are present in Novasel No. 1. The Southside Harbour deposit was outlined in a feasibility study for the potential development of a soda ash industry sponsored by the Nova Scotia Department of Trade and Industry in the early 1950's. In the Mabou area, the Mabou deposit is the only deposit recognized and it is defined by four deep petroleum exploration boreholes. The salt deposits and occurrences in the Antigonish-Mabou area are described in the following order: Antigonish, James River, Mabou, Ohio, Pomquet River and Southside Harbour.

GENERAL GEOLOGY

The Antigonish-Mabou area contains rocks with a rather complex history. The major geological divisions as summarized in the following paragraphs are intended to briefly outline the general geological configuration of the area (Fig. 6-1).

The oldest rocks in the Antigonish area are located in the Antigonish Highlands (Fig. 1-1) and comprise Middle-Lower Paleozoic and possibly Proterozoic sedimentary, volcanic and intrusive rocks. To the northeast and east, in the Mabou area, the oldest rocks occur in the Creignish Hills and comprise highly deformed Proterozoic sedimentary, volcanic and intrusive rocks (Fig. 1-1). To the north, the Mabou area is bounded by the Mabou Highlands which comprise Middle Paleozoic intrusive rocks and younger sedimentary and volcanic rocks.

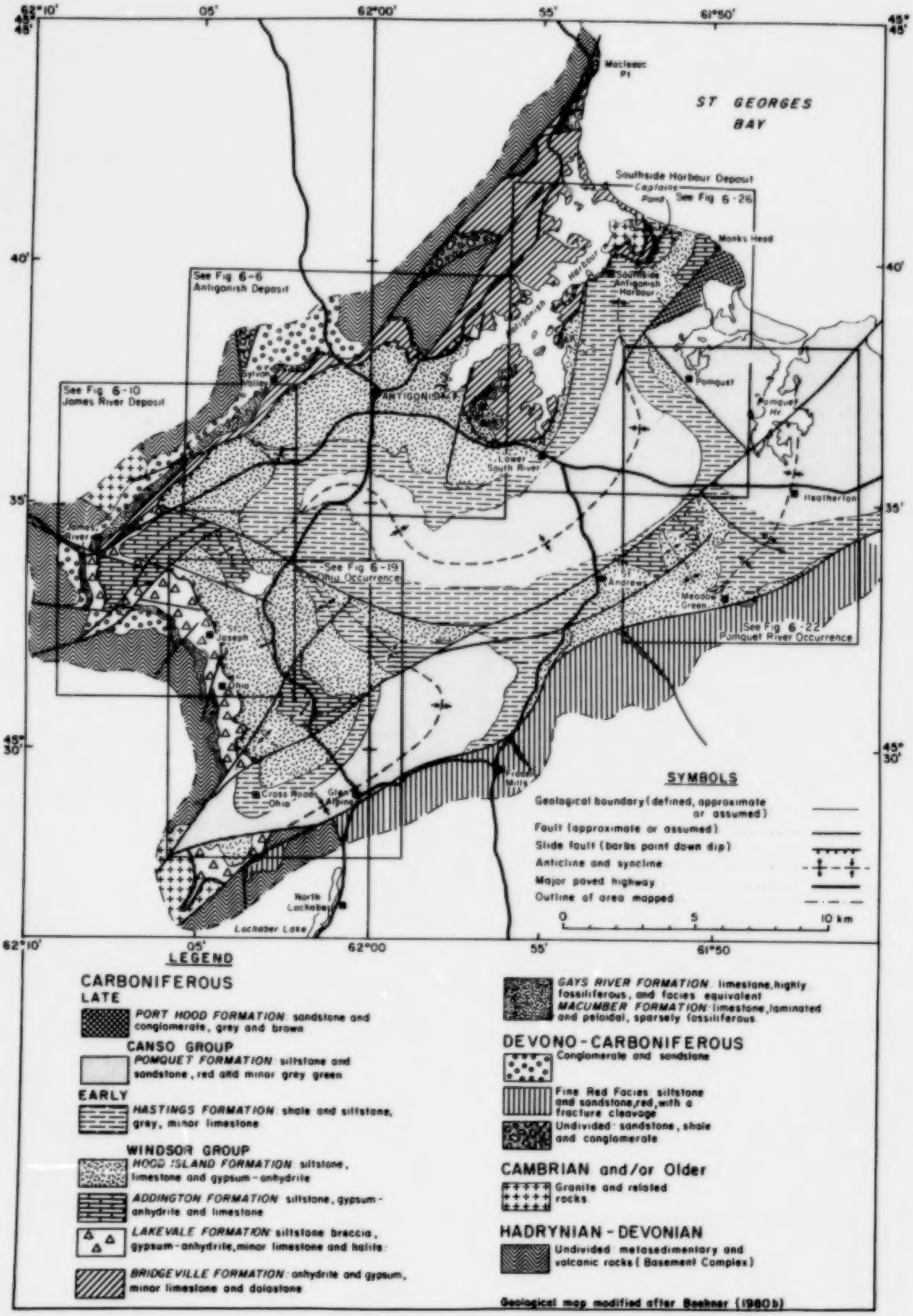
Sedimentary rocks, including sandstone, conglomerate, and shale of the Lower Carboniferous Horton Group (Figs. 6-2 and 6-3) occur along the southeastern border of the area. These rocks were deposited on top of and marginal to the older rocks of highland areas, such as the Mabou Highlands, Creignish Hills, and Cape George area to the north of Antigonish. The lowland parts of the Antigonish-Mabou area are underlain by shale, evaporites, including halite, anhydrite and gypsum, and limestone strata of the Lower Carboniferous Windsor Group. The Windsor Group is overlain in the central part of the area by a thick succession of Upper Carboniferous strata comprising the Canso, Riversdale and locally Pictou Groups.

The stratigraphy of the Windsor Group in the Antigonish-Mabou area has been studied and described by various workers including Sage (1954), Stacey (1953), Norman (1935), Boehner (1980b), and Boehner and Giles (1982). These studies outlined the general geology in the area, but were hindered to varying degrees by structural complications, limited exposure, and only a few boreholes. Locally Windsor Group evaporites have migrated to form diapirs contributing to the already rather complex structure that reflects adjustment of basement blocks. Structural trends in the Carboniferous rocks appear in general to be oriented to the northeast and north, with less well-defined trends at varying angles to the major trend. Boehner (1980a) and Boehner and Giles (1982) reported the presence of a major thrust fault at the top of the main salt section in the Antigonish Basin.

The Antigonish Thrust Fault predates the latest movement of the series of northeasterly trending longitudinal faults. The majority of the rocks outcropping in the Antigonish Basin (above the main salt section) are inferred to be allochthonous. Thrust faulting and evaporite diapirism are also inferred (but not confirmed) to be present in the Mabou area.

The Windsor Group (Fig. 6-4) in the Antigonish area comprises a succession of fossiliferous limestone, gypsum, anhydrite, halite, and thick siltstone. Generally these rocks rest conformably on strata of the Horton Group although they locally overlap onto pre-Carboniferous rocks. Several northeasterly trending faults to the north of Antigonish bring Windsor Group strata in contact with Horton Group or pre-Carboniferous Browns Mountain Group rocks or both.

Sage (1954) stated that the stratigraphy in the Antigonish area was compiled by piecing together many small and badly broken sections and by comparisons to the relatively intact, but incomplete Port Hood Island section, and the Windsor Group type section at Windsor. Although he stated that the Pomquet River and the Monks Head sections were the most complete Windsor Group sections in relation to the number of limestone units present, he also indicated that over one half of the Pomquet River section was overturned and the Monks Head section was "shuffled like a pack of cards." He concluded the Windsor Group had an approximate average thickness of between 600 and 900 m.



62°10'
05'
62°00'
55'
61°50'
45° 45'
40'
35'
45° 30'
ST GEORGES BAY
Maclsaac Pt
Southside Harbour Deposit
Captains Pond
See Fig 6-26
Monks Head
Southside Antigonish Harbour
Antigonish Harbour
See Fig 6-6 Antigonish Deposit
Sylvan Valley
ANTIGONISH
See Fig 6-10 James River Deposit
Pomquet
Pomquet Hr
Lower South River
Heatherton
James River
See Fig 6-19 Ohio Occurrence
St Andrews
Meadow Green
See Fig 6-22 Pomquet River Occurrence
Joseph
Ohio
Cross Roads Ohio
Glen Alpine
Fraser Mills
North Lochaber
Lochaber Lake
SYMBOLS
Geological boundary (defined, approximate or assumed)
Fault (approximate or assumed)
Slide fault (barbs point down dip)
Anticline and syncline
Major paved highway
Outline of area mapped
0
5
10 km
LEGEND
CARBONIFEROUS
LATE
PORT HOOD FORMATION: sandstone and conglomerate, grey and brown
CANSO GROUP
POMQUET FORMATION: siltstone and sandstone, red and minor grey green
EARLY
HASTINGS FORMATION: shale and siltstone, grey, minor limestone
WINDSOR GROUP
HOOD ISLAND FORMATION: siltstone, limestone and gypsum-anhydrite
ADDINGTON FORMATION: siltstone, gypsum-anhydrite and limestone
LAKEVALE FORMATION: siltstone breccia, gypsum-anhydrite, minor limestone and halite
BRIDGEVILLE FORMATION: anhydrite and gypsum, minor limestone and dolostone
GAYS RIVER FORMATION: limestone, highly fossiliferous, and facies equivalent
MACUMBER FORMATION: limestone, laminated and peloidal, sparsely fossiliferous
DEVONO-CARBONIFEROUS
Conglomerate and sandstone
Fine Red Facies: siltstone and sandstone, red, with a fracture cleavage
Undivided: sandstone, shale and conglomerate
CAMBRIAN and/or Older
Granite and related rocks
HADRYNIAN - DEVONIAN
Undivided metasedimentary and volcanic rocks (Basement Complex)
Geological map modified after Boehner (1980b)

Figure 6-1. Geological map of the Antigonish Basin showing salt deposits geological map areas.

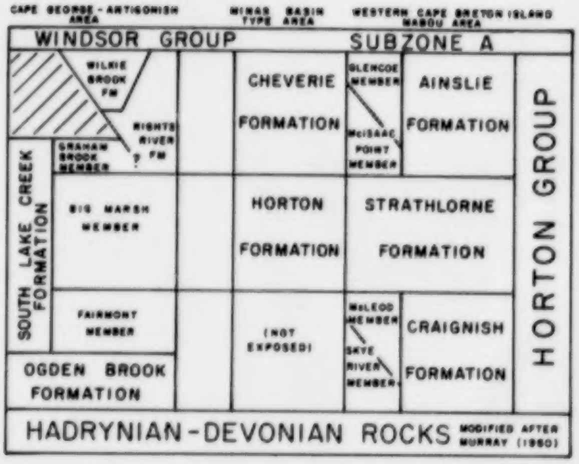

CAPE GEORGE - ANTIGONISH AREA
MINAS BASIN TYPE AREA
WESTERN CAPE BRETON ISLAND MABOU AREA
WINDSOR GROUP
SUBZONE A
WILKIE BROOK FM
RIGHTS RIVER FM
GRAHAM BROOK MEMBER
?
SOUTH LAKE CREEK FORMATION
BIG MARSH MEMBER
FAIRMONT MEMBER
OGDEN BROOK FORMATION
CHEVERIE FORMATION
HORTON FORMATION
(NOT EXPOSED)
GLENCOE MEMBER
McISAAC POINT MEMBER
McLEOD MEMBER
SKYE RIVER MEMBER
AINSLIE FORMATION
STRATHLORNE FORMATION
CRAIGNISH FORMATION
HORTON GROUP
HADRYNIAN-DEVONIAN ROCKS
MODIFIED AFTER MURRAY (1960)

Figure 6-2. Horton Group stratigraphy and general correlation, Antigonish-Mabou area, Nova Scotia.

The stratigraphic section of the fossiliferous limestone units is the basis of Sage's (1954) subdivision of the Windsor Group in the Antigonish area. These units based in part upon work by Stacey (1953) in Cape Breton were assigned to the faunal subzones defined by Bell (1929) and were given numerical subscripts in ascending order. These units, together with the corresponding lithologic names for the Antigonish area (after Sage, 1954), are as follows:

Subzone	Unit Number	Informal Name
E	E_1	Schizodus
D	D_3	No Name
	D_2	No Name
	D_1	Giant Ripple
C	C_3	Columnar Algal
	C_2	No Name
	C_1	Small Algal
B	B_3	1st oolitic
	B_2	2nd oolitic
	B_1	Quarry
A	A_2	Canary
	A_1	Basal, Ribbon, "sandy limy"

According to Sage (1954) the Upper Windsor and B Subzone sections comprise approximately 244 m (800 ft.). His stratigraphic placement of the salt and the Quarry or B_1 limestone, in the Windsor Group in the Southside Harbour area, has been revised based upon more recent work by Boehner and Giles (1982), Boehner (1980b), Giles et al. (1979) and deep drilling by Brador Oil Company Limited in 1975 (Farries Engineering Ltd., 1976). These studies have recognized the occurrence of locally developed, highly fossiliferous A Subzone limestone banks where the Windsor Group onlaps pre-Carboniferous rocks and oversteps the Horton Group. This limestone is thicker than the more areally extensive laminated limestone that occurs throughout the area, generally overlying the Horton Group. This laminated limestone unit is variously referred to as the A_1 (basal sandy) limestone (Sage, 1954), Ribbon limestone (Stacey, 1953), Macumber limestone (Schenk, 1967a,b, 1969) and Macumber Formation (Boehner and Giles, 1982). The fossiliferous banks of the Gays River Formation bear a fauna similar to the B Subzone. They are developed on favourable topographic highs, thin rapidly into a more widespread sporadically fossiliferous laminated facies and are overlain by a thick, massive anhydrite unit (Bridgeville Formation) typical of the A Subzone in the Shubenacadie area.

In Sage's (1954, p. 44) Southside Harbour cross-section the B_1 or Quarry limestone (Gays River Formation) rests with distinct angular unconformity on a pre-Carboniferous granite knob and is overlain by a thick anhydrite-gypsum (Bridgeville Formation) which in turn is overlain with faulted contact by a thick red and grey siltstone section (Hastings Formation). Salt of the Hartshorn Formation is encountered eastward from the basement high and is separated from the thick red siltstone section by the Antigonish Thrust Fault. Deep drilling for petroleum by Brador Oil Company Limited in 1975 (Farries Engineering Ltd., 1976) in Southside Harbour No. 1, indicated that the Hartshorn Formation salt is thick (greater than 120 m) and overlies the thick Bridgeville Formation anhydrite (110 m) which in turn, overlies the Gays River Formation-Macumber Formation limestone (basal Windsor Group). The Windsor Group rests upon a thick (greater than 425 m) section of Horton Group which unconformably overlies granitoid rocks.

Sage (1954) indicated the salt is part of the B Subzone, however, it is probable that a better case may be made for A Subzone assignment for the salt-gypsum section and the quarry limestone (Fig. 6-28). The salt may occur as a lateral stratigraphic and possible facies equivalent in part (though not entirely time equivalent) of the thick anhydrite unit. This is a very similar interpretation to that of the Shubenacadie-Stewiacke deposit (Fig. 2-25). These stratigraphic relations may explain the salt deposits in the western part of the Antigonish area and in particular the James River-Ohio area. At this location fossiliferous basal Windsor limestone (Gays River Formation) rests with angular unconformity on pre-Carboniferous rocks (Stewart, 1976) and is overlain by a thick anhydrite unit (Bridgeville Formation) which in turn is overlain by a variably thick section of salt (Hartshorn Formation).

The A Subzone section in the Antigonish Basin is overlain with uncertain relationship by the B Subzone and the Upper Windsor (Addington and Hood Island Formations). Boehner (1980b) postulated the existence of a major thrust fault at this contact. This part of the section comprises approximately 244 m (800 ft.) of intercalated red siltstone or sandstone with thin gypsum, anhydrite and fossiliferous limestone (B_2, B_3, C_1, C_2, C_3, D_1, D_2, D_3, and E_1 units of Sage, 1954). The Milk Plant section near

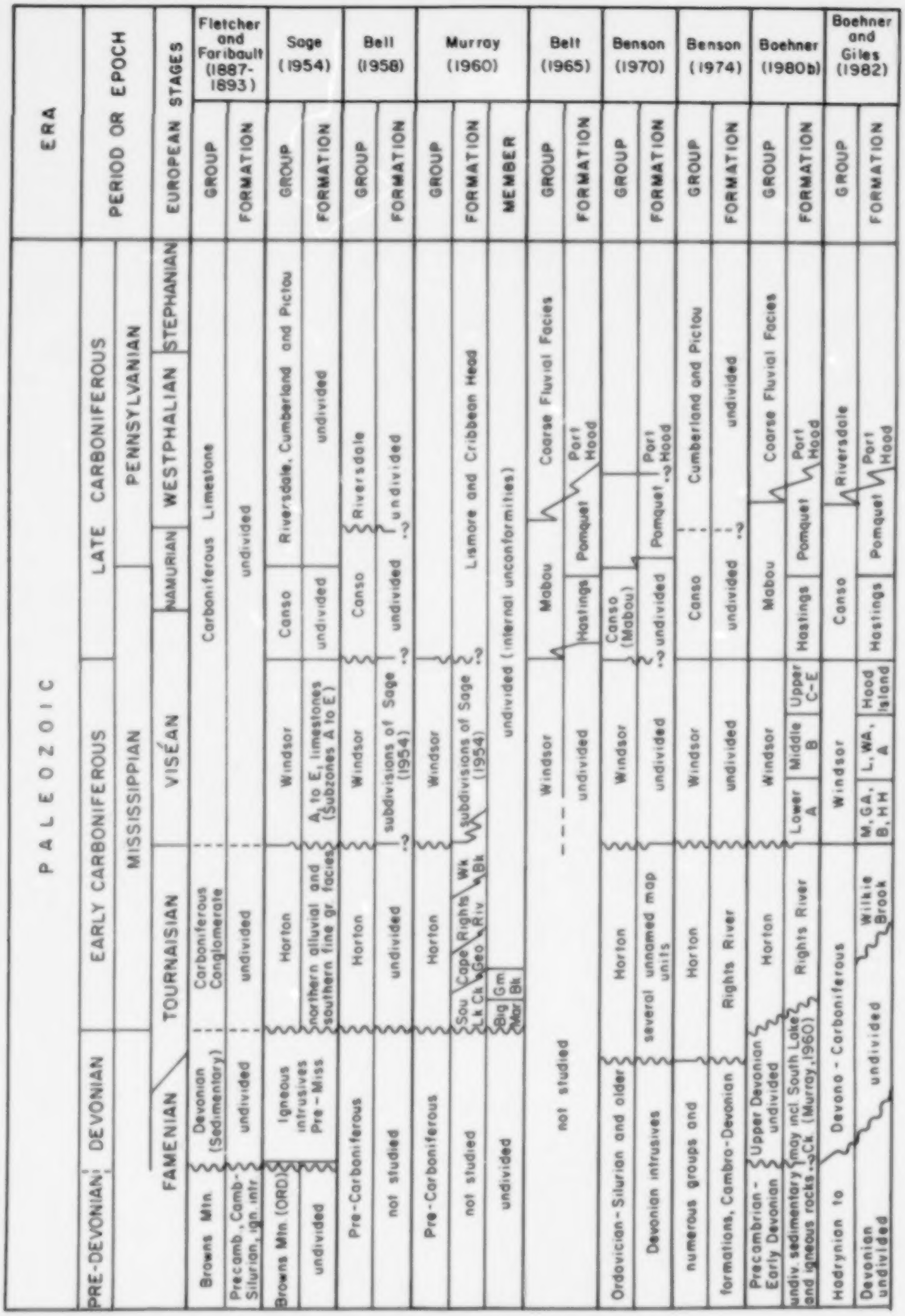

ERA
PERIOD OR EPOCH
EUROPEAN STAGES
PALEOZOIC
PRE-DEVONIAN
DEVONIAN
EARLY CARBONIFEROUS
LATE CARBONIFEROUS
MISSISSIPPIAN
PENNSYLVANIAN
FAMENIAN
TOURNAISIAN
VISÉAN
NAMURIAN
WESTPHALIAN
STEPHANIAN
Fletcher and Faribault (1887-1893)
GROUP
FORMATION
Browns Mtn.
Devonian (Sedimentary)
Carboniferous Conglomerate
Carboniferous Limestone
Precamb., Camb-Silurian, ign. intr
undivided
Sage (1954)
Browns Mtn. (ORD)
Igneous intrusives Pre-Miss
Horton
Windsor
Canso
Riversdale, Cumberland and Pictou
northern alluvial and southern fine gr facies
A to E, limestones (Subzones A to E)
Bell (1958)
Pre-Carboniferous
not studied
subdivisions of Sage (1954)
Riversdale
Murray (1960)
MEMBER
Sou Lk Ck
Cape Geo
Rights Riv
Wk Bk
Big Mar
Gm Bk
Lismore and Cribbean Head
undivided (internal unconformities)
Belt (1965)
Mabou
Hastings
Pomquet
Coarse Fluvial Facies
Port Hood
Benson (1970)
Ordovician-Silurian and older
Devonian intrusives
several unnamed map units
Canso (Mabou)
Benson (1974)
numerous groups and formations, Cambro-Devonian
Rights River
Cumberland and Pictou
Boehner (1980b)
Precambrian - Early Devonian
undiv. sedimentary and igneous rocks may incl. South Lake Ck (Murray, 1960)
Upper Devonian undivided
Lower A
Middle B
Upper C-E
Boehner and Giles (1982)
Hadrynian to Devonian undivided
Devono - Carboniferous
Wilkie Brook
M, GA, B, HH
L, WA, A
Hood Island
?

Figure 6-3. Summary of Antigonish Basin stratigraphic nomenclature with approximate age correlation. Conformable section (stated, inferred)——- - - -; Unconformity ᨓ ; Facies boundary ᨓ ; Contact relations unspecified and uncertain — ? —; M = Macumber, GR = Gays River, B = Bridgeville, HH = Hartshorn, L = Lakevale, WA = Wallace, A = Addington.

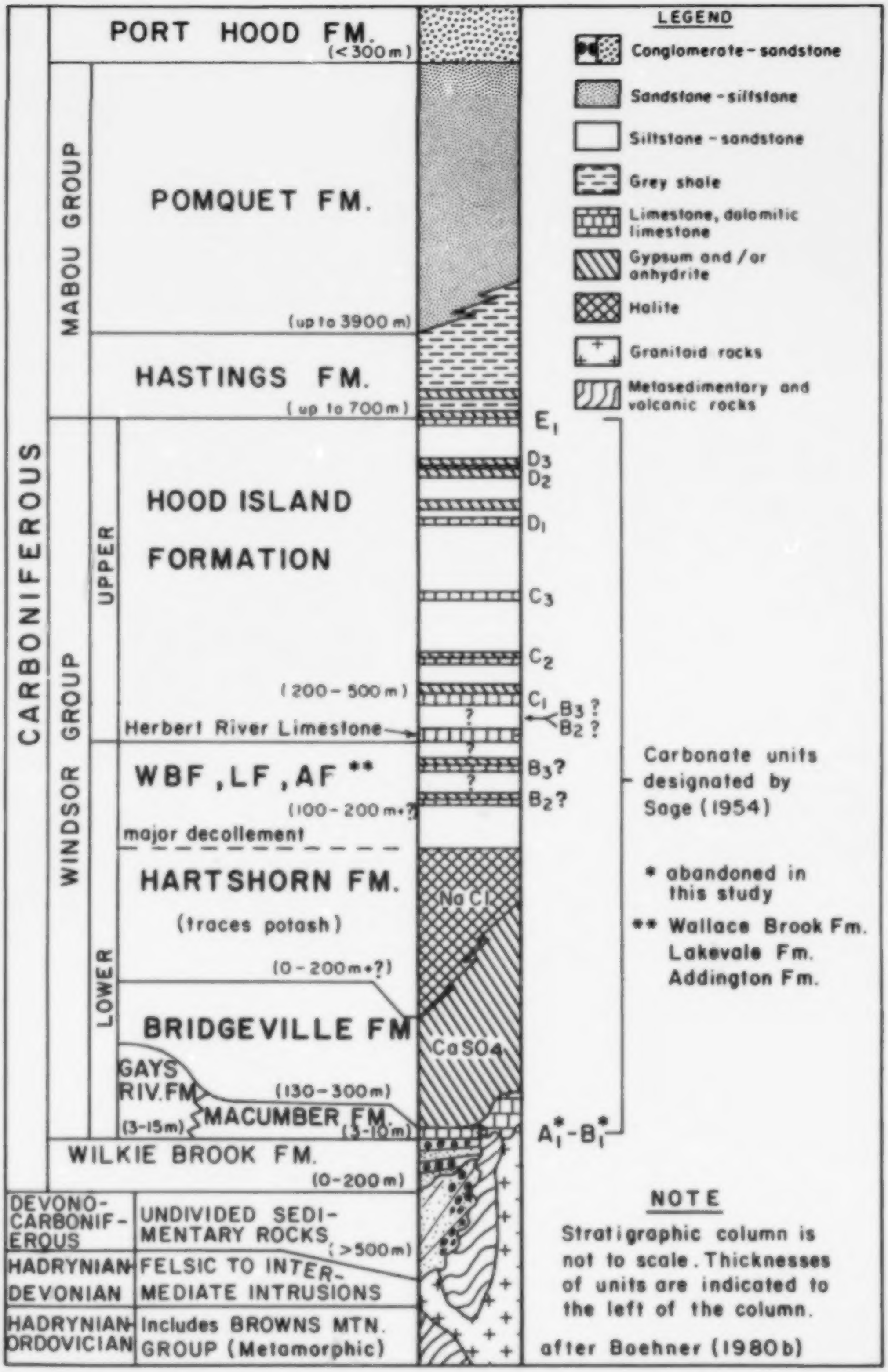

PORT HOOD FM.
(< 300 m)
MABOU GROUP
POMQUET FM.
(up to 3900 m)
HASTINGS FM.
(up to 700 m)
CARBONIFEROUS
WINDSOR GROUP
UPPER
HOOD ISLAND FORMATION
(200 - 500 m)
Herbert River Limestone
LOWER
WBF, LF, AF **
(100 - 200 m+?)
major decollement
HARTSHORN FM.
(traces potash)
(0 - 200 m+?)
BRIDGEVILLE FM
GAYS RIV. FM
(130 - 300 m)
(3-15 m)
MACUMBER FM.
(3-10 m)
WILKIE BROOK FM.
(0-200 m)
DEVONO-CARBONIFEROUS
UNDIVIDED SEDIMENTARY ROCKS
(> 500 m)
HADRYNIAN-DEVONIAN
FELSIC TO INTERMEDIATE INTRUSIONS
HADRYNIAN-ORDOVICIAN
Includes BROWNS MTN. GROUP (Metamorphic)
NaCl
CaSO4
E1
D3
D2
D1
C3
C2
C1
B3?
B2?
B3?
B2?
A1*-B1*
LEGEND
Conglomerate - sandstone
Sandstone - siltstone
Siltstone - sandstone
Grey shale
Limestone, dolomitic limestone
Gypsum and / or anhydrite
Halite
Granitoid rocks
Metasedimentary and volcanic rocks
Carbonate units designated by Sage (1954)
* abandoned in this study
** Wallace Brook Fm. Lakevale Fm. Addington Fm.
NOTE
Stratigraphic column is not to scale. Thicknesses of units are indicated to the left of the column.
after Boehner (1980b)

Figure 6-4. Stratigraphic column for Antigonish Basin.

Antigonish described by Sage (1954) has anomalously thick, clastic interbeds. Locally, thin gypsum beds may overlie the limestone units, for example the C_1, C_2 and D_1 of the Monks Head section.

Boehner and Giles (1982) subdivided this part of the section into four formations including the Addington, Lakevale, Wallace Brook and Hood Island (Fig. 6-4). The alphanumeric carbonate member designations of Sage (1954) were retained with the exception of the A_1 (Macumber Formation), A_2, and B_1 (Gays River Formation) which were abandoned.

The total thickness of the A Subzone evaporite section is not certain because of the lack of data and the thrust fault at contact with the poorly-defined younger B Subzone strata. Estimated thicknesses for this package are probably in the order of 300 to 460 m. Sage (1954) reported approximately 580 m (1900 ft.) of section for the entire Windsor Group as exposed in the Pomquet River section. Although the average total thickness for the entire Windsor Group is probably in the order of 550 to 760 m, thicker sections may be present in the St. Georges Bay area and northwest of the Captains Pond - Williams Point basement high trend.

The stratigraphy of the Windsor Group in the western part of Cape Breton was studied and described by Norman (1935) and Stacey (1953). Norman (1935) recognized a two part ("member") subdivision of the Windsor Group. The Lower Windsor is exposed in partial sections on Port Hood Island and on Mabou Harbour. On Port Hood Island Norman (1935) reported a thickness of 319 m (1047 ft.) for the upper part of the Lower Windsor Group composed of red shales, gypsum and limestone. At Mabou Mines the lower part of the Lower Windsor section is a 126 m (415 ft.) thick section composed of A_1 limestone (Macumber Formation) overlain by a thick anhydrite unit (Fig. 6-5). Both sections are incomplete due to faulting. Locally the Port Hood Island section is also highly disturbed and incomplete.

The upper subdivision of the Windsor Group, Norman (1935) indicated, is best developed on Port Hood Island and is approximately equivalent to the Upper Windsor zone of Bell (1929). In this section, stratigraphic intervals in the Upper Windsor are nearly twice as thick as some equivalent sections in the Antigonish area. The Upper Windsor of Norman (1935), on Port Hood Island comprises approximately 198 m (650 ft.) of interbedded red shale, limestone, gypsum and anhydrite. The total Windsor Group section was indicated by Norman (1935) to be approximately 610 m (2000 ft.) thick.

Stacey (1953) studied the Windsor Group stratigraphy in parts of Cape Breton Island and indicated a total thickness of 670-825 m (2200-2700 ft.) in the Mabou-Judique area in western Cape Breton. He indicated the exposure on Port Hood Island to be the most complete in the area. It contains approximately 457 m (1500 ft.) of Upper Windsor and B Subzone units to which he applied the following terminology, B_2, B_3, C_1, C_2, C_3, D_1, D_2, D_3, and E_1 (Fig. 6-5).

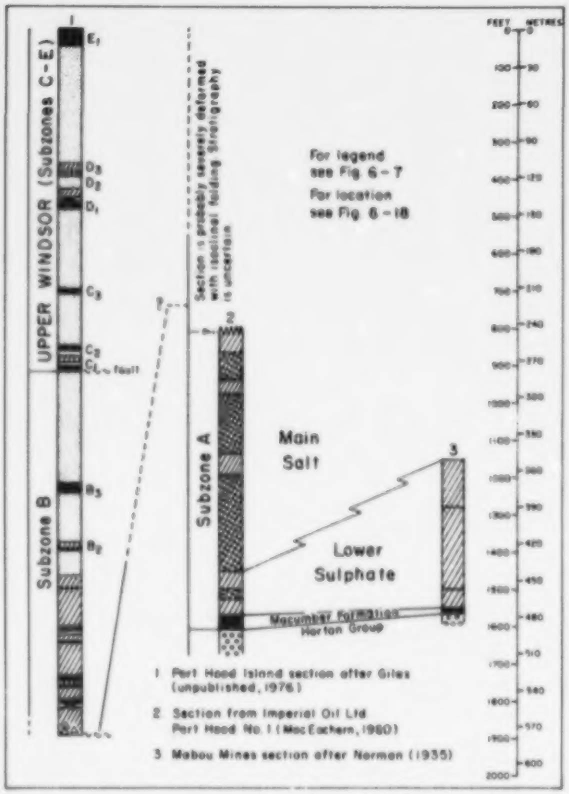

1
UPPER WINDSOR (Subzones C-E)
Subzone B
E_1
D_3
D_2
D_1
C_3
C_2
C_1 ~ fault
B_3
B_2
Section is probably severely deformed with isoclinal folding. Stratigraphy is uncertain
?
2
Subzone A
Main Salt
Lower Sulphate
3
Macumber Formation
Horton Group
For legend see Fig. 6-7
For location see Fig. 6-18
FEET
METRES
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
1 Port Hood Island section after Giles (unpublished, 1976)
2 Section from Imperial Oil Ltd Port Hood No. 1 (MacEachern, 1980)
3 Mabou Mines section after Norman (1935)

Figure 6-5. Preliminary Windsor Group stratigraphic columns, Antigonish-Mabou area.

In the Port Hood Island section the Upper Windsor C_1-E_1 units are approximately 305 m (1000 ft.) thick, the B_2-C_1 section is approximately 150 m (500 ft.) and the deformed gypsum beneath the B_2 is approximately 107 m (350 ft.) thick.

Stacey (1953) postulated the section between the lowermost gypsum on Port Hood Island and the A_1 basal limestone in ascending order as follows:

200'± Salt
? Maroon siltstone
40'± B_1 limestone.
Subzone A
? Maroon siltstone
20-60' A_2 limestone
10-100' Maroon siltstone
30-50' A_1 limestone
HORTON GROUP

In proposing this section Stacey (1953) used as a reference the Southside Harbour area that was being investigated at the time by Sage (1954). Sage (1954) considered the salt and Quarry (B_1) limestone to be part of the B Subzone. Reinterpretation of this cross-section and the recognition of a fossiliferous A Subzone basal limestone in other areas suggest that the lower parts of the section, including the salt and Quarry limestone, are probably part of the A Subzone.

ANTIGONISH DEPOSIT

The Antigonish deposit (NTS 11F/12 and 11E/09) is located approximately 3.5 km west of Antigonish, Antigonish County, Nova Scotia (Figs. 1-10 and 6-6).

The area is readily accessible through a series of paved and unpaved roads connected with the Trans-Canada Highway 104. The Canadian National Railway mainline between Stellarton and Port Hawkesbury is located approximately 2.5 km north of the deposit.

The terrain in the vicinity is typical of Carboniferous Antigonish Lowlands with gently undulating hills and elevations rarely exceeding 75 m. The lowland area is bordered on the north by the Antigonish Highlands, comprising older Paleozoic rocks which rise rapidly to elevations of up to 300 m.

HISTORICAL BACKGROUND

Salt springs and seeps were described in the vicinity of Antigonish area by Dawson (1868), who reported that a boring operation for salt brine was undertaken in the area of the "harbour landing place". Strong salt brine was reported to have been encountered. Fletcher (1887) indicated the presence of salt springs in the area and described the history of the salt venture located near Town Point approximately 9 km northeast of Antigonish.

> Salt springs and ponds are found everywhere in the neighborhood of the gypsum, as at Pomquet, and South Rivers, Brierly Brook, Addington Forks, and other places. Salt was made many years ago from the salt pond near the town of Antigonish. In May, 1866, a company called the Nova Scotia Salt Works and Exploration Company, was incorporated under the management of Mr. Josiah Deacon, to conduct boring operations to discover the source of the brine. The first boring was sunk on Town Point, near the mouth of the harbour, a six-inch borehole, lined with iron tubing, being driven through a considerable thickness of soil and clay, then through a thick band of gypsum into sandstones, without finding any indication of brine; so that further operations in this locality were abandoned.
>
> Encouraged by indications of salt water and salt on the surface, where the railway station now stands, a second borehole was put down here; and a nine-inch cast-iron pipe sunk through sixteen feet of gravel, full of weak surface brine. The auger then passed through red, blue and brown marl, with thin bands of fibrous gypsum; then through several layers of magnesian sandstone, striking a bed of gypsum 141 feet from the surface.
>
> After penetrating 18 feet into the gypsum, there was a flow of pure, strong, limpid brine from a cleft, which flowed nearly to the surface, could only be lowered a few feet by pumping, and discharged a large volume of sulpheretted hydrogen gas. A large steam engine was erected for pumping, and furnaces, tanks and evaporating pans of large dimensions, constructed for the production of salt. After the manufacture of a considerable quantity of salt, the strength of the brine became very much reduced. Another borehole was accordingly put through clays to a depth of 650 feet, but finding no indications of brine, that of the other boring being too weak for use, and the working capital exhausted, the work was abandoned.

Pohl (in Hayes, 1931) located four salt springs in the area of the Antigonish deposit (probably the same as indicated by Fletcher, 1887); one near Brierly Brook, another near Antigonish and two near Salt Springs. These were sampled and analyzed by Cole (1930a).

In 1953 the Malagash Salt Company drilled two holes (NSDM 1977, 1978) to maximum depth of 226 m in exploration for salt approximately 1.5 km east of Antigonish, but no salt was encountered. The geology of the Antigonish area (11F/12), in particular the Windsor Group, was described and mapped by Sage (1954).

In 1966 Kenneco Explorations (Canada) Limited (Grace, 1966) explored the Antigonish area for salt-sulphur-potash and base metal deposits. A diamond-drill hole, KEH-1 was drilled on a Bouguer gravity minimum located approximately midway between Salt Springs and Brierly Brook. Salt was intersected between 319 and 366 m (1047 and 1201 ft.) and the hole was ultimately stopped at 371 m (1217 ft.)

In 1974 Amax Exploration Incorporated contracted the Nova Scotia Research Foundation to recompute old and new gravity data in the area. Two Bouguer gravity minima were outlined, one near Addington Forks on the west (James River deposit) and one centred near Salt Springs, 3.5 km west of Antigonish. Amax drilled AP-2-74 near the centre of the latter anomaly approximately 1.6 km southeast of KEH-1. Salt mixed with shale was intersected between 387 and 486 m (1271 and 1594 ft.). This hole was completed at 556.6 m (1826 ft.).

GEOLOGY

The geology in the vicinity of the Antigonish deposit was mapped and described by Benson (1970, 1974) and Sage (1954), but it is only recently that the Windsor Group has been described and mapped in subdivided units (Boehner, 1980a; Boehner and Giles, 1982).

The oldest rocks in the area outcrop to the north and northwest in the Antigonish Highlands. These folded and faulted sedimentary, metamorphic, and intrusive rocks are assigned to the Hadrynian-Devonian. They are overlain with angular unconformity by Devono-Carboniferous strata comprising conglomerate, sandstone and shale. The Windsor Group comprises gypsum, anhydrite, halite, red shales and limestone and rests conformably upon the Devono-Carboniferous strata.

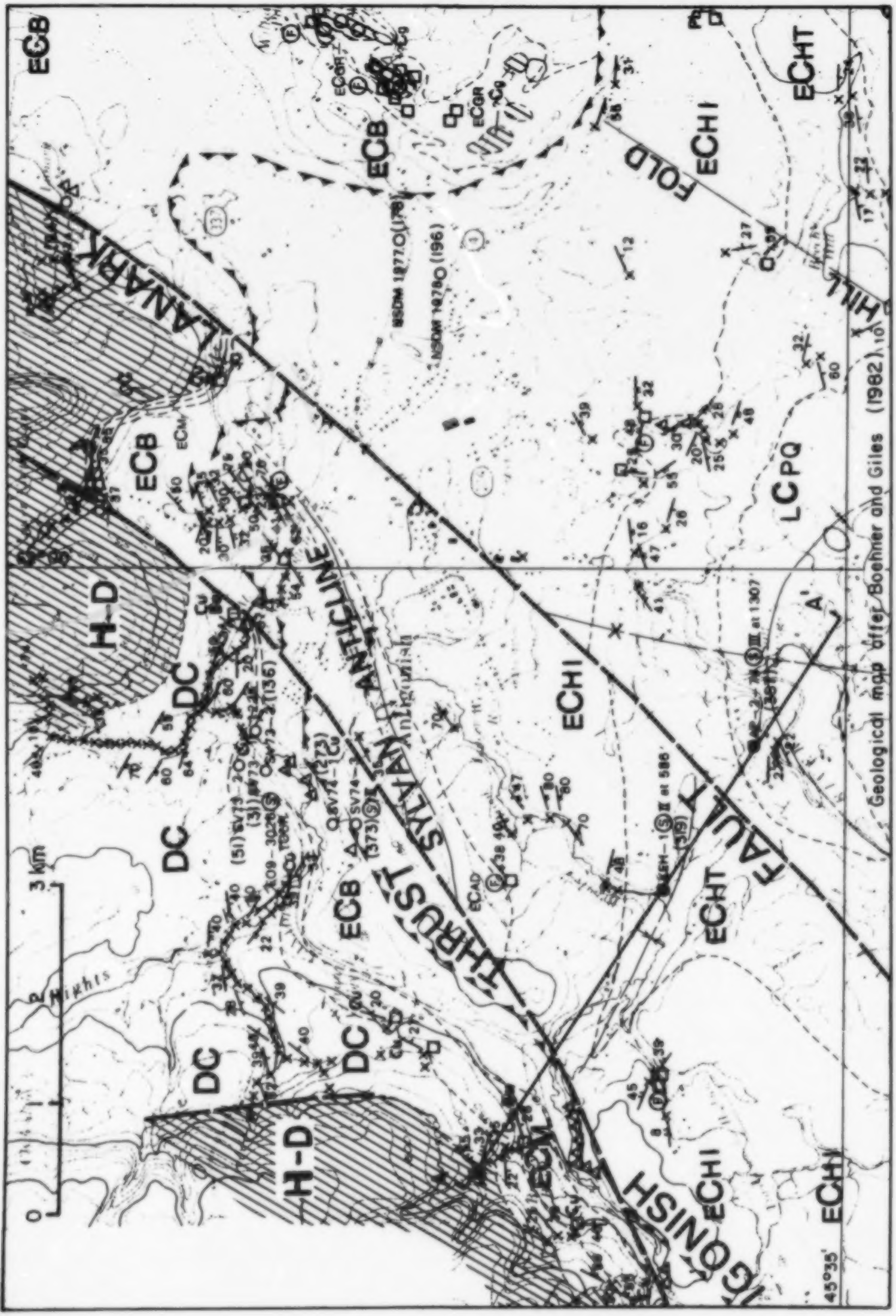
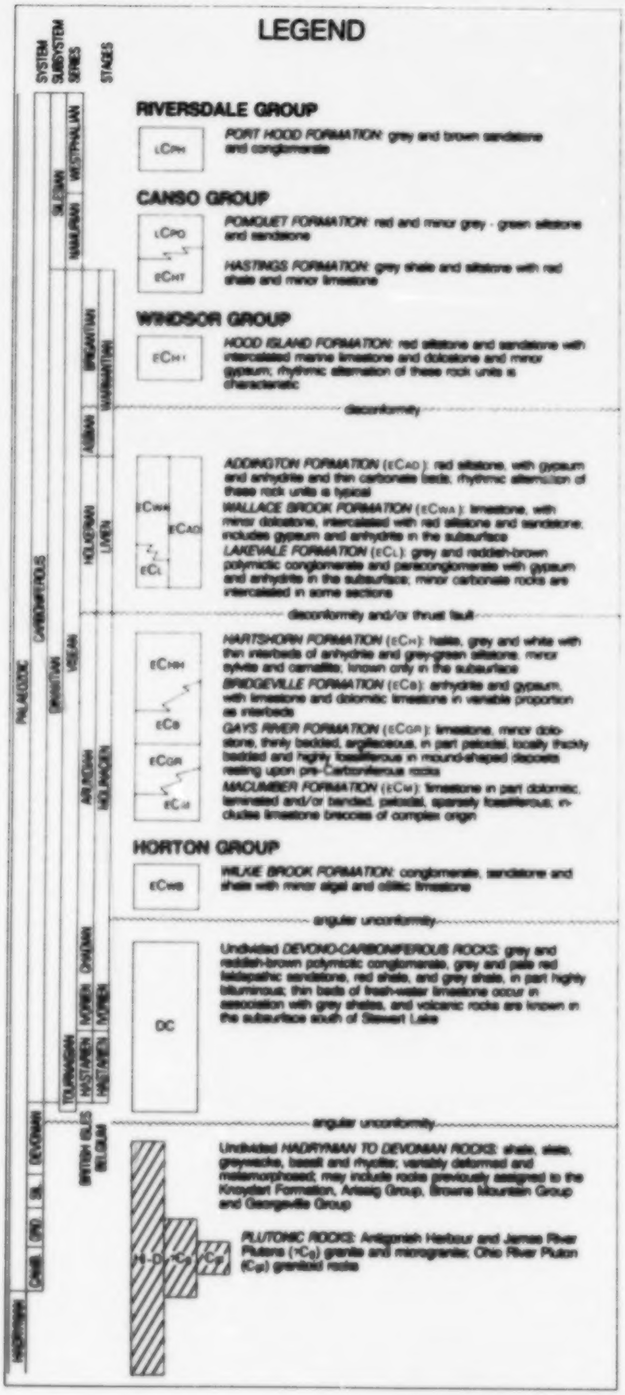

0
3 km
45°35'
H-D
H-D
DC
DC
DC
DC
ECB
ECB
ECB
ECM
ECHI
ECHI
ECHI
ECHI
ECHT
ECHT
LCPQ
ECGB
ECAD
ECGR
LANARK
THRUST
SYLVAN ANTICLINE
ANTIGONISH
FAULT
HILL
FOLD
A
A'
SDM 1977
SDM 1978

Figure 6-6. Geological map and legend, Antigonish deposit.

Geological map after Boehner and Giles (1982).

LEGEND



RIVERSDALE GROUP

PORT HOOD FORMATION: grey and brown sandstone and conglomerate

CANSO GROUP

POMQUET FORMATION: red and minor grey - green siltstone and sandstone

HASTINGS FORMATION: grey shale and siltstone with red shale and minor limestone

WINDSOR GROUP

HOOD ISLAND FORMATION: red siltstone and sandstone with intercalated marine limestone and dolostone and minor gypsum; rhythmic alternation of these rock units is characteristic

disconformity

ADDINGTON FORMATION (eCAD): red siltstone, with gypsum and anhydrite and thin carbonate beds; rhythmic alternation of these rock units is typical

WALLACE BROOK FORMATION (eCWA): limestone, with minor dolostone, intercalated with red siltstone and sandstone; includes gypsum and anhydrite in the subsurface

LAKEVALE FORMATION (eCL): grey and reddish-brown polymictic conglomerate and paraconglomerate with gypsum and anhydrite in the subsurface; minor carbonate rocks are intercalated in some sections

disconformity and/or thrust fault

HARTSHORN FORMATION (eCH): halite, grey and white with thin interbeds of anhydrite and grey-green siltstone, minor sylvite and carnallite; known only in the subsurface

BRIDGEVILLE FORMATION (eCB): anhydrite and gypsum, with limestone and dolomitic limestone in variable proportion as interbeds

GAYS RIVER FORMATION (eCGR): limestone, minor dolostone, thinly bedded, argillaceous, in part peloidal, locally thickly bedded and highly fossiliferous in mound-shaped deposits resting upon pre-Carboniferous rocks

MACUMBER FORMATION (eCM): limestone in part dolomitic, laminated and/or banded, peloidal, sparsely fossiliferous; includes limestone breccias of complex origin

HORTON GROUP

WILKIE BROOK FORMATION: conglomerate, sandstone and shale with minor algal and oolitic limestone

angular unconformity

Undivided *DEVONO-CARBONIFEROUS ROCKS:* grey and reddish-brown polymictic conglomerate, grey and pale red feldspathic sandstone, red shale, and grey shale, in part highly bituminous; thin beds of fresh-water limestone occur in association with grey shales, and volcanic rocks are known in the subsurface south of Stewart Lake

angular unconformity

Undivided *HADRYNIAN TO DEVONIAN ROCKS:* shale, slate, greywacke, basalt and rhyolite; variably deformed and metamorphosed; may include rocks previously assigned to the Knoydart Formation, Arisaig Group, Browns Mountain Group and Georgeville Group

PLUTONIC ROCKS: Antigonish Harbour and James River Plutons (?Cg) granite and microgranite; Ohio River Pluton (Cg) granitoid rocks

SYMBOLS

Rock outcrop limestone, dolostone; commonly fossiliferous	▢
gypsum, anhydrite	△
terrigenous sedimentary and volcanic rocks	×
granitoid rocks	○
areas with continuous outcrop	
Bedding; horizontal, inclined, vertical, overturned, tops unknown	+ / / / /
Geological boundary, approximate, dotted beneath major bodies of water	
Fault, approximate, dotted beneath major bodies of water	━ ━ ·····
relative fault movement wrench fault	⇄
symbol on downthrown side	┴
Thrust fault, barbs point down-dip	▾▾ ▾▾
Anticline and syncline	
Antiform and synform	
Anticline and syncline, overturned	
Fossil locality	Ⓕ
Spore locality (zonation after Utting - 1978, 1980)	ⓢ
Diamond-drill hole	● 2
Mine or quarry, ls - limestone	⚒ ls
Mineral occurrence or prospect, Pb - lead, Zn - zinc, Cu - copper, Ba - barite, Fl - fluorite	▢ Pb
Rb - Sr whole rock isochron age (^{87}Rb) = 1.42 x 10^{11}/yr	533 ± 19
Drillhole intesecting salt, number (depth to salt in metres)	● AP-1-? (408)
Drillhole, number (total depth in metres)	○ AF-1 (278)

In general, the geology in the deposit area appears to define a northeasterly trending syncline as a continuation of the syncline graben inferred to occur in the James River area to the southwest. Boehner (1980b) and Boehner and Giles (1982) indicated this configuration is complicated by the Antigonish Thrust Fault (Fig. 6-6).

Diamond-drilling on the Bouguer gravity low near Antigonish by Kenneco Explorations (Canada) Limited (Grace, 1966) in 1966 (KEH-1) and Amax Exploration Incorporated in 1974 (AP-2-74) indicates a moderate to steeply dipping thick section of red siltstone and fine sandstone with rare thin gypsum and very rare limestone beds overlying the salt (Fig. 6-7). KEH-1 intersected a section of Hastings Formation overlying the Hood Island Formation which is incomplete at its base because of the Antigonish Thrust Fault immediately above the Hartshorn Formation salt. Spore data obtained from a depth of 398 m (1307 ft.) in AP-2-74, indicate the strata are probably Canso Group.

Drilling in the Sylvan Valley area by Imperial Oil in 1973 and 1974 (Ward, 1974) confirmed the presence of a thick section of the Bridgville Formation anhydrite overlying the Macumber Formation limestone which overlies Devono-Carboniferous conglomerate and sandstone (Figs. 6-7 and 6-8). In one hole SV74-3, a section of red shale with minor limestone was described above the Bridgeville Formation, but salt was not reported (Ward, 1975a).

In 1953 the Malagash Salt Company drilled two exploration holes NSDM 1977 and 1978 near Williams Point (Fig. 6-6 and 6-7). Salt was not reported in these holes and the section of limestone, shale and gypsum intersected is probably part of the Hood Island Formation. The presence of the basal Windsor Group section at Williams Point indicates the possibility of a fault along the southern side or in Antigonish Harbour. A single hole SV74-2 was drilled by Imperial Oil near Lanark in 1974. The hole, drilled with a dip of 45° on an azimuth of 315°, intersected a section of gypsum and was abandoned in a thick unconsolidated solution trench at 125 m (410 ft.). This zone of poor recovery coincides with the Lanark Fault (Fig. 6-6).

In 1976 U.S. Borax (Pacific Coast Exploration) drilled four holes near Lower South River (LSR-1 to -4, Figs. 6-7 and 6-26). A thick section of Bridgeville Formation anhydrite overlying Gays River Formation limestone was intersected in these holes. The limestone at Lower South River is fossiliferous and rests with nonconformity on granitoid and volcanic rocks.

GEOPHYSICS

A Bouguer gravity anomaly map (11E/09) by the Nova Scotia Research Foundation (1974; Fig. 6-9) indicates a small (6 mGal) minimum coincident with the Antigonish deposit. Small gravity maxima situated north and east of Antigonish and northwest of the deposit appear to coincide with the Bridgeville Formation (anhydrite) outcrop areas. Further exploration drilling will be required to establish the thickness and extent of the salt indicated by the gravity data.

GEOCHEMISTRY

Salt springs and seeps in the area were sampled and analyzed by Cole (1930a). Cole described and reported analyses (Table 6-1) on the following four springs:

> Etheridge Springs (Nos. 21 and 22). Two saline springs occur on the farm of Howard Etheridge, Salt Springs P.O., Antigonish County. The stronger one (No. 21) occurs on the east bank of West River. The flow is small but the water bubbles up quite freely on occasions. In the meadow back of the house there are several shallow saline ponds (No. 22) and, although no spring nor inlet is visible, they remain distinctly saline even after heavy rains.
>
> Brierly Brook Spring (No. 26). The most strongly saline spring of the district is found on the north side of Brierly Brook, 2 1/2 miles west-southwest of Antigonish station, on the land of Martin Somers. The spring occurs at the west end of a small shallow pond at the base of a low escarpment and there is a flow out of this pond of about 5 gallons per minute. Another saline pond occurs 75 feet to the southwest of the main one, but there are no visible springs in it.
>
> Antigonish Spring (No. 27). In the meadow land around the creek which runs along the southeastern outskirts of the town there is a brine pond in which several weakly flowing springs bubble up. The flow out of this pond is approximately 2 gallons per minute.

The chemistry of the salt springs is typical of moderately $CaSO_4$ enriched NaCl springs in Nova Scotia. No. 22 is anomalous in its Mg content, but none appear to be anomalous in K content.

ECONOMIC CONSIDERATIONS

The Antigonish deposit consists of halite. No potash has been reported. Salt of unknown purity was intersected in two drillholes, AP-2-74 and KEH-1, drilled on a Bouguer gravity minimum centred between Brierly Brook and Salt Springs. In KEH-1 salt was intersected between 319 and 366 m, and in AP-2-74 between 387 and 486 m. Salt springs and seeps are common in the area.

The deposit is located adjacent to the Trans-Canada Highway 104 and the Canadian National Railway mainline between Stellarton and Port Hawkesbury. The deposit area has potential for further salt exploration and possibly may contain potash salts.

JAMES RIVER DEPOSIT

The James River deposit is located approximately 2 km south of James River (NTS 11E/09) and 12 km

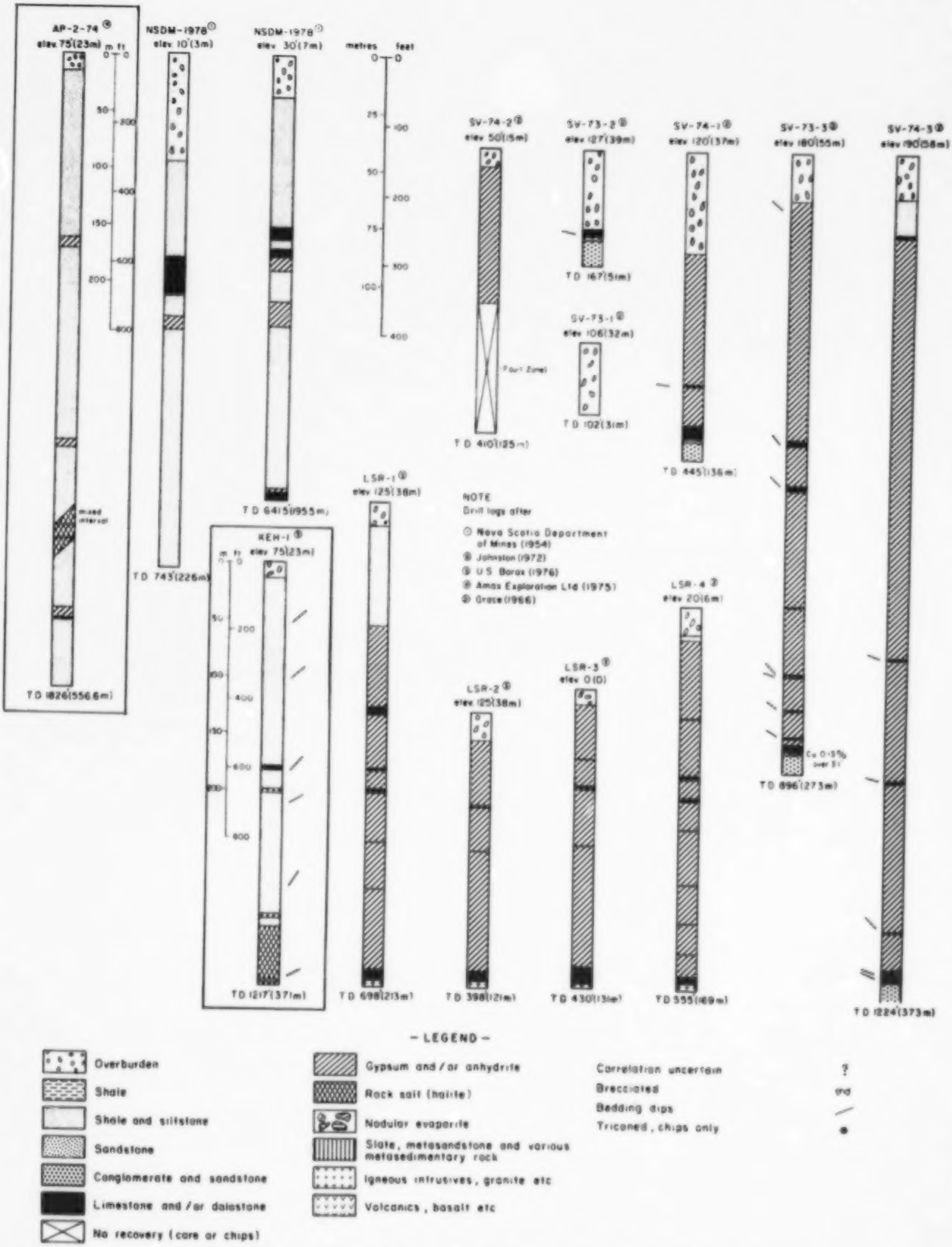
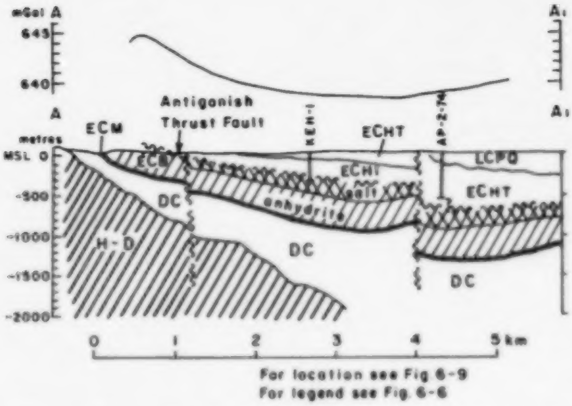

AP-2-74
elev 75'(23m)
m ft
0 0
50 200
100 400
150 600
200 800
mixed interval
T D 1826'(556.6m)
NSDM-1978
elev 10'(3m)
T D 743'(226m)
NSDM-1978
elev 30'(7m)
T D 6415'(1955m)
metres feet
0 0
25 100
50 200
75 300
100 400
SV-74-2
elev 50'(15m)
Fault Zone
T D 410'(125m)
SV-73-2
elev 127'(39m)
T D 167'(51m)
SV-73-1
elev 106'(32m)
T D 102'(31m)
SV-74-1
elev 120'(37m)
T D 445'(136m)
SV-73-3
elev 180'(55m)
Cu 0.5% over 3'
T D 896'(273m)
SV-74-3
elev 190'(58m)
T D 1224'(373m)
KEH-1
elev 75'(23m)
m ft
0 0
50 200
100 400
150 600
200 800
T D 1217'(371m)
LSR-1
elev 125'(38m)
T D 698'(213m)
LSR-2
elev 125'(38m)
T D 398'(121m)
LSR-3
elev 0(0)
T D 430'(131m)
LSR-4
elev 20'(6m)
T D 555'(169m)
NOTE
Drill logs after
① Nova Scotia Department of Mines (1954)
② Johnston (1972)
③ U.S. Borax (1976)
④ Amax Exploration Ltd (1975)
⑤ Grace (1966)
- LEGEND -
Overburden
Shale
Shale and siltstone
Sandstone
Conglomerate and sandstone
Limestone and/or dolostone
No recovery (core or chips)
Gypsum and/or anhydrite
Rock salt (halite)
Nodular evaporite
Slate, metasandstone and various metasedimentary rock
Igneous intrusives, granite etc
Volcanics, basalt etc
Correlation uncertain ?
Brecciated
Bedding dips
Triconed, chips only

Figure 6-7. Drillhole profiles, Antigonish deposit.


mGal A
A₁
645
640
A
A₁
Antigonish Thrust Fault
KEH-1
AP-2-74
metres
MSL 0
-500
-1000
-1500
-2000
ECM
ECB
ECHT
ECHI
salt
anhydrite
LCPQ
ECHT
DC
H-D
DC
DC
0
1
2
3
4
5 km

For location see Fig.6-9
For legend see Fig.6-6

Figure 6-8. Bouguer gravity and geological cross-section, Antigonish deposit.

west of Antigonish, Antigonish County, Nova Scotia (Figs. 1-10 and 6-10).

The area is readily accessible from a series of paved and unpaved roads connected to the Trans-Canada Highway 104 which passes approximately 1 km north of the deposit area. The mainline of Canadian National Railway between Port Hawkesbury and Stellarton is located approximately 1.5 km north of the area.

The deposit is located in gently rolling terrain with elevations rarely exceeding 75 m in the Antigonish Lowlands which are underlain by Carboniferous strata. The Lowlands are bordered on the west and north by the older Paleozoic rocks of Antigonish Highlands where elevations rise rapidly to 225 m and locally exceed 300 m.

HISTORICAL BACKGROUND

The possible presence of salt rocks in the James River area was first indicated by the occurrence

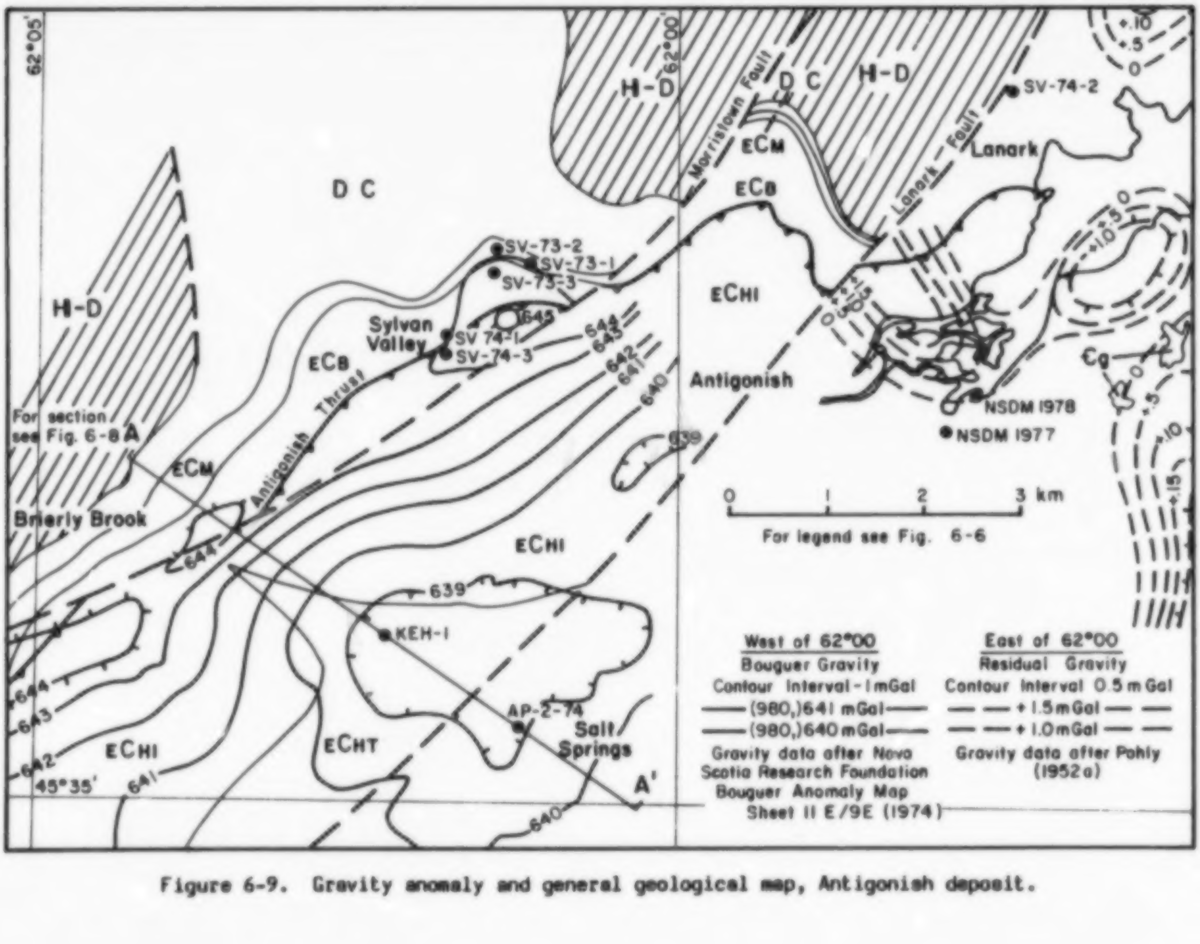

62°05'
62°00'
H-D
D C
H-D
Morristown Fault
Lanark Fault
SV-74-2
Lanark
ECM
ECB
D C
H-D
SV-73-2
SV-73-1
SV-73-3
Sylvan Valley
SV 74-1
SV-74-3
645
644
643
642
641
640
639
ECHI
Antigonish
ECB
Antigonish Thrust
For section see Fig. 6-8 A
ECM
Brierly Brook
644
639
KEH-1
AP-2-74
Salt Springs
ECHI
ECHT
ECHI
644
643
642
641
640
45°35'
A'
NSDM 1978
NSDM 1977
Cg
+.10
+.5
0
0
+.5
+1.0
0
+.5
+.10
+.15
0
1
2
3 km
For legend see Fig. 6-6
West of 62°00
Bouguer Gravity
Contour Interval - 1 mGal
(980,)641 mGal
(980,)640 mGal
Gravity data after Nova Scotia Research Foundation Bouguer Anomaly Map Sheet 11 E/9E (1974)
East of 62°00
Residual Gravity
Contour Interval 0.5 m Gal
+1.5 m Gal
+1.0 m Gal
Gravity data after Pohly (1952a)

Figure 6-9. Gravity anomaly and general geological map, Antigonish deposit.

Table 6-1. Analyses of salt springs, Antigonish deposit*

SPRING NO.	21	22	26	27
FIELD NOTES AT TIME OF SAMPLING				
Temperature of atmosphere, °F	72	72	65	73
Temperature of brine, °F	50	72	48	55
Baume degrees	6.5	1.5	6.75	3.5
Equivalent specific gravity ..	1.045	1.010	1.046	1.024
LABORATORY NOTES				
Specific gravity at 60° F	1.0335	1.0168	1.0175	1.0277
Total solids at 110°C	4.41	2.13	6.55	3.77
Reaction	N	N	N	N
ANALYSES OF SOLIDS				
Na .... Per cent	33.22	32.18	34.53	34.07
K .... Per cent	0.13	0.09	0.11	0.14
Ca .... Per cent	3.26	3.87	2.50	3.00
Mg .... Per cent	0.14	0.43	0.09	0.23
SO_4 .... Per cent	.50	9.68	6.15	6.35
Cl .... Per cent	51.65	50.60	53.61	53.94
Br .... Per cent	none	none	none	none
I .... Per cent	none	none	none	none
Total	96.90	96.85	96.99	97.73
HYPOTHETICAL COMBINATION				
$CaSO_4$ .... Per cent	11.06	13.16	8.64	9.00
$CaCl_2$ .... Per cent	0.83	-	-	0.97
$MgSO_4$ .... Per cent	-	0.49	-	-
$MgCl_2$ .... Per cent	-	1.24	0.35	0.90
K_2SO_4 .... Per cent	-	-	-	-
KCl .... Per cent	0.12	0.17	0.21	0.26
Na_2CO_4 .... Per cent	-	-	-	-
NaCl .... Per cent	84.85	81.79	87.78	86.60
Total	96.86	96.85	96.98	97.73

*Cole (p. 9, 1930a)

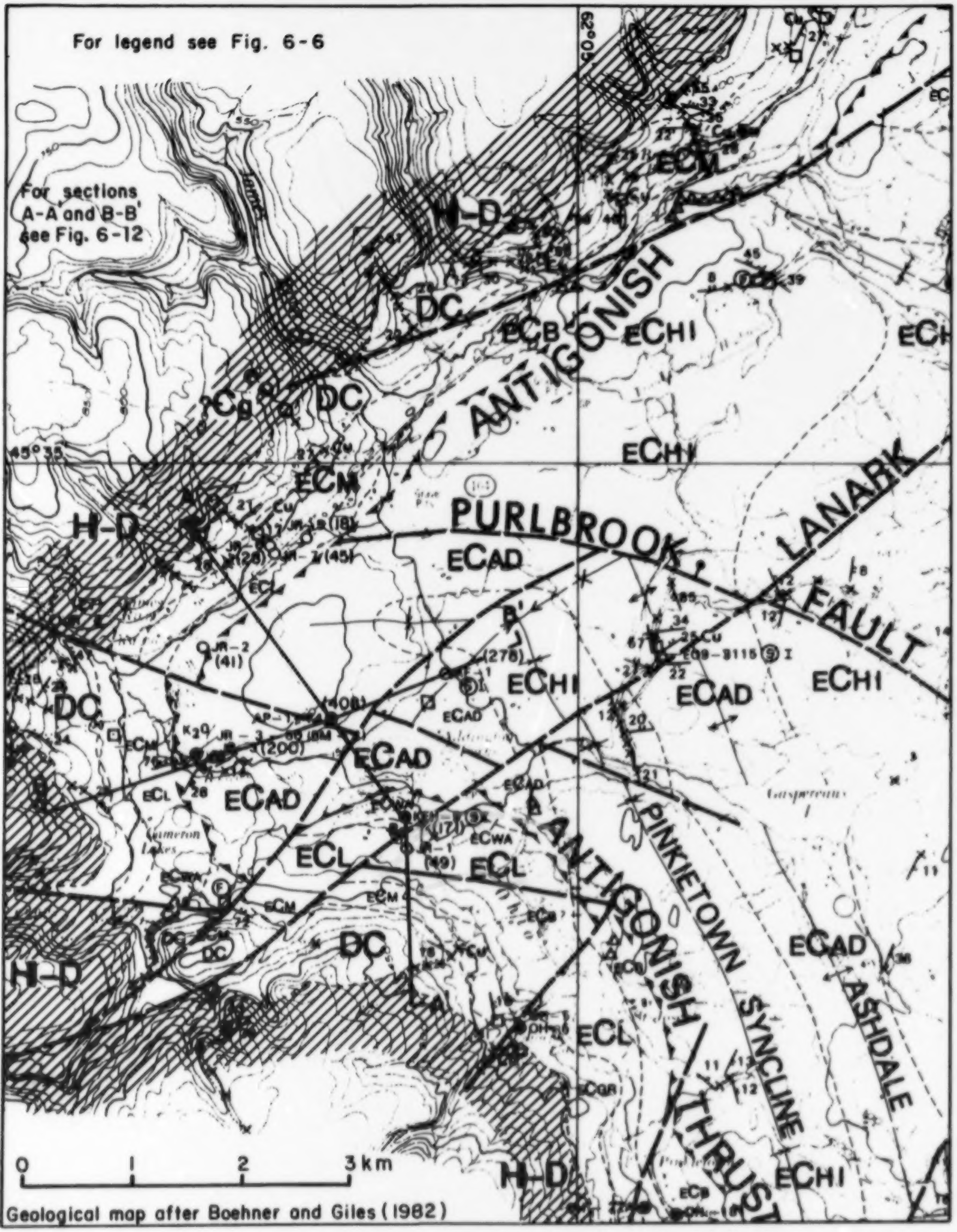
of salt springs and seeps. Fletcher (1887) stated that salt springs and ponds are found in the neighbourhood of gypsum at places such as Brierly Brook and Addington Forks. Pohl (in Hayes, 1931) recorded the occurrence of many salt springs and seeps in the "Antigonish Basin", twelve of which were located and sampled. Several were located immediately to the east of the James River-Addington Forks area. These samples were analyzed and described by Cole (1930a). The area was determined by Pohl (in Hayes, 1931) to require much more detailed examination before it could be adequately assessed for its salt and potash potential.

Pohly (1952a and b) indicated the occurrence of a gravity minimum in the James River-Addington Forks area, but felt that the structure and gravity could not be reliably interpreted from the data available.

More recently mineral exploration by Kenneco Explorations (Canada) (1966) (Grace, 1966), Millmor-Rogers Syndicate (1974), Amax (1975) and Ward (1974, 1975b) has established the presence of salt and potash in the area.

GEOLOGY

The geology in the vicinity of the James River deposit (Fig. 6-10) has been described by Benson


For legend see Fig. 6-6
For sections A-A' and B-B' see Fig. 6-12
60°05'
45°35'
H-D
DC
ECB
ECHI
ECM
ECAD
ECL
ECWA
ECu
ANTIGONISH
PURLBROOK
LANARK
FAULT
ANTIGONISH
PINKIETOWN SYNCLINE
THRUST
ASHDALE
A
A'
B
B'
JR-2 (41)
JR-3
JR-7 (45)
(278)
(408)
(200)
(17)
(49)
Cameron Lakes
Gaspereaux
0
1
2
3 km

Geological map after Boehner and Giles (1982)

Figure 6-10. Geological map, James River deposit, Antigonish County.

(1974), Boehner (1980b) and Boehner and Giles (1982). In general, the Lower Carboniferous Windsor Group which contains major salt deposits is located in the Antigonish Lowlands and overlies with apparent conformity rocks assigned to the Devono-Carboniferous. These rocks, comprising sandstone, conglomerate and shale, rest with angular unconformity on the faulted and folded sedimentary, metamorphic, and intrusive rocks that outcrop west and north in the Antigonish Highlands.

The Windsor Group comprises interstratified gypsum, anhydrite, halite, red siltstone and shale, and limestone. To the north and northwest the Windsor Group overlies a thin outcrop band of Devono-Carboniferous, but to the west it appears to rest unconformably on the older rocks of the Antigonish Highlands. The rocks in the deposit area have been disrupted by faulting and folding to produce a complicated structural configuration (Fig. 6-10). Faults in the area are of three major types; high angle longitudinal (northeast trending), high angle transverse (northwest trending), and low angle thrust. Latest movement has occurred on the northeasterly trending faults, but the most important fault related to the salt in the area is the Antigonish Thrust. All strata above the Hartshorn Formation salt are allochthonous. The upper part of the salt is highly deformed and the presence of minor potash near the top may be all that remains of significant deposits that have been removed by faulting and/or subsequent dissolution.

The JR-3 drillhole (Figs. 6-10 and 6-11) drilled by 1973 Millmor-Rogers Syndicate (1974) intersected red shales to approximately 140 m, gypsum, limestone, and shale to 207 m and was abandoned in Hartshorn Formation salt at 250 m. This hole was redrilled nearby in 1980 by Cuvier Mines Ltd. (Black, 1981) (BM-1, JR-3-80) to a total depth of 343 m (1124 ft.). Approximately 30.5 m (100 ft.) of salt with minor potash were intersected in faulted contact with Bridgeville Formation anhydrite below and Addington Formation above.

KEH-5 is situated approximately 2 km southwest of JR-3 (Figs. 6-10 and 6-11) and was drilled by Kenneco Explorations (Canada) Limited (1966) (Grace, 1966). This hole intersected red shale, limestone and gypsum with a few veins of halite to a depth of approximately 300 m, red shales to 430 m, fractured anhydrite and then fractured laminated limestone to 450 m. It was believed to have been stopped in Horton Group at 471.5 m. Diamond-drilling further south along the contact with the Antigonish Highlands basement complex, by Kenneco Explorations (Canada) Limited and Imperial Oil Limited, has intersected fossiliferous Windsor Group limestone (Gays River Formation).

AP-1-74 (Figs. 6-10 and 6-11) was drilled approximately 1.1 km northeast of JR-3 by Amax Exploration Ltd. (1975). This hole intersected red shales to 130 m, anhydrite and gypsum to 180 m, red shales to 400 m, salt to 620 m and was abandoned in anhydrite at 675.4 m. The AF-1 drillhole (Burton *in* Ward, 1975b), located approximately 1.1 km northeast of AP-1-74, was drilled by Imperial Oil and intersected red shale, gypsum, anhydrite and two limestone beds. It was stopped at 278 m without reaching salt. The JR-3, AP-1-74 and AF-1 drillholes are inferred to lie in or very near the axis of a synclinal trough (Figs. 6-10 and 6-12).

GEOPHYSICS

The Bouguer gravity anomaly map for the James River area (Fig. 6-13) has a Bouguer minimum centred near Addington Forks which is pear shaped, trends northeasterly and connects with another minimum centred near Salt Springs (Fig. 6-6).

To the northwest of the Addington Forks minimum there are three contiguous gravity maxima paralleling the northwestern contact. These probably represent the outcrop belt of anhydrite and the pre-Carboniferous basement (Fig. 6-12). South and east of the Addington Forks minimum a broad triangular shaped maximum occurs with its centre located near St. Joseph. This high coincides with outcrop and subcrop area of Bridgeville Formation anhydrite overlying basement with thin intervening Devono-Carboniferous sediments.

GEOCHEMISTRY

The only available analyses (Table 6-2) of salt in the James River deposit are those in an unpublished B.Sc. honours thesis by Stewart (1976).

The average analysis of the salt sampled over the 478.5-605.3 m (1570-1986 ft.) interval is 69% NaCl (calculated from Na). The calculation of NaCl from Na gives a low value because of the difficulty in measuring Na at high concentrations. Possibly a better assessment of the salt quality may be obtained by assuming the NaCl approximately equals 100% minus per cent water insoluble.

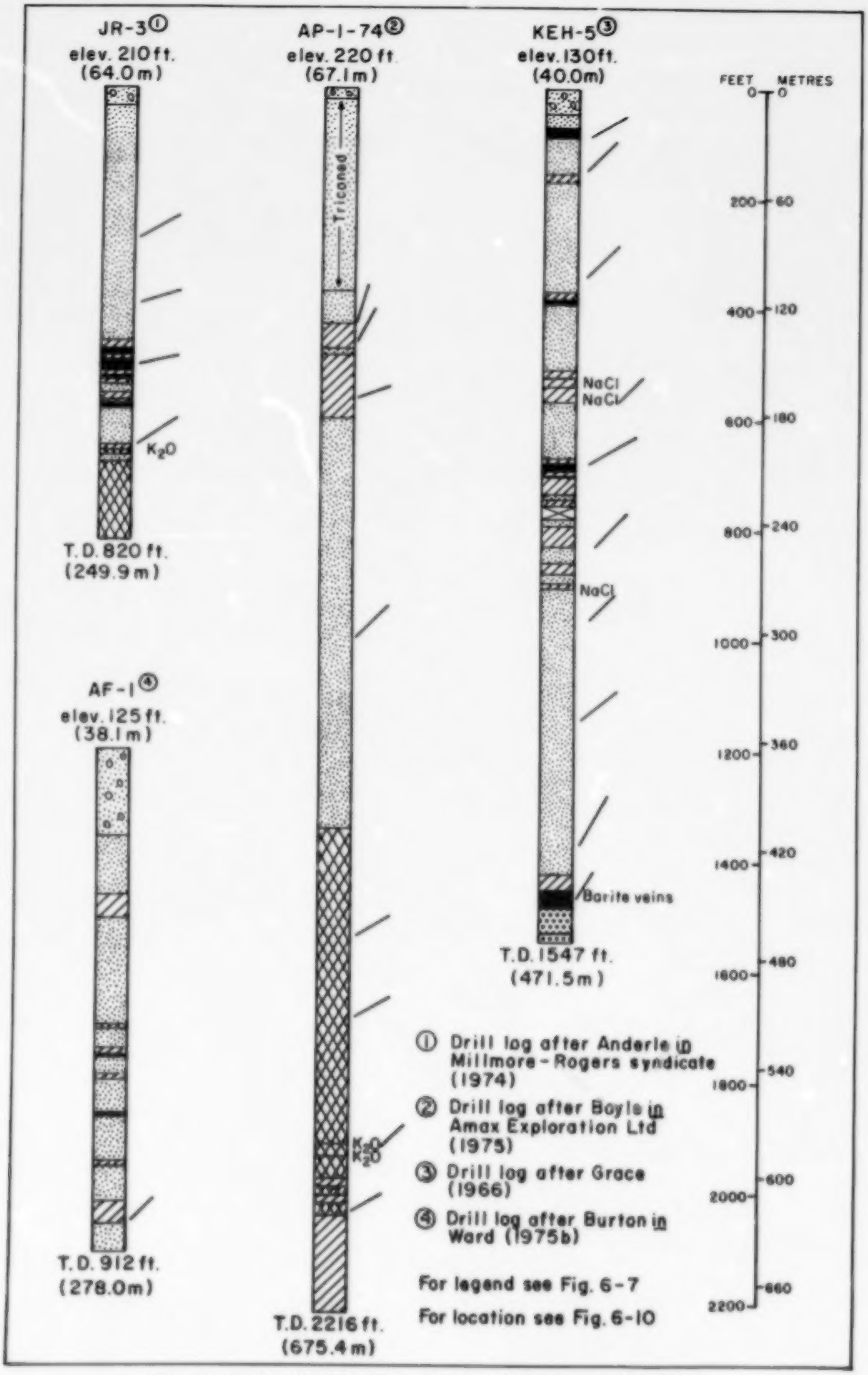
ECONOMIC CONSIDERATIONS

The James River deposit consists of halite with thin (less than 4 m) intervals of low grade (1-6.25%, K_2O) potash reported in two drillholes, AP-1-74 and JR-3. In the thickest known section, from AP-1-74, the salt was intersected in the interval 408.4-621.2 m (1340-2038 ft.). Analyses of the salt from AP-1-74 by Stewart (1976) indicate an average NaCl content of 69% in samples taken from the interval 478.5-605.3 m (1570-1986 ft.).

The size of the deposit has not been established by drilling, but based on the associated Bouguer gravity anomaly, it probably is approximately 3000 m long, 1500 m wide, and 100 m thick.

Salt springs are reported in the deposit area, but are much more common in the Salt Springs area immediately to the east.

The deposit is located adjacent to the Trans-Canada Highway 104 and Canadian National Railway mainline that runs between Stellarton and Sydney.


JR-3①
elev. 210 ft.
(64.0 m)
K$_2$O
T.D. 820 ft.
(249.9 m)
AF-1④
elev. 125 ft.
(38.1 m)
T.D. 912 ft.
(278.0 m)
AP-1-74②
elev. 220 ft.
(67.1 m)
Triconed
K$_2$O
K$_2$O
T.D. 2216 ft.
(675.4 m)
KEH-5③
elev. 130 ft.
(40.0 m)
NaCl
NaCl
NaCl
Barite veins
T.D. 1547 ft.
(471.5 m)
FEET
METRES
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
60
120
180
240
300
360
420
480
540
600
660

① Drill log after Anderle in Millmore-Rogers syndicate (1974)

② Drill log after Boyls in Amax Exploration Ltd (1975)

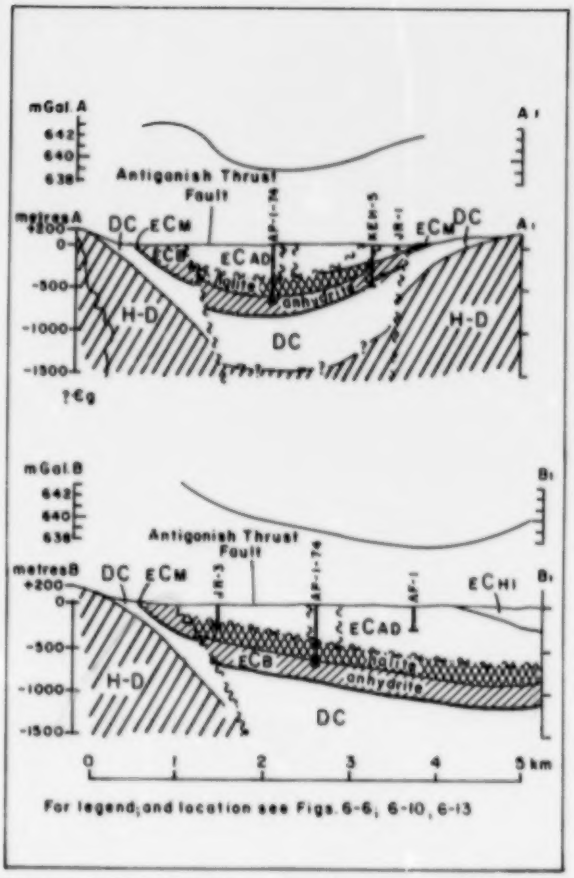
③ Drill log after Grace (1966)

④ Drill log after Burton in Ward (1975b)

For legend see Fig. 6-7

For location see Fig. 6-10

Figure 6-11. Drillhole profiles, James River deposit.


mGal A
642
640
638
A'
Antigonish Thrust Fault
metres A
+200
0
-500
-1000
-1500
DC
ECM
ECB
ECAD
halite
anhydrite
H-D
DC
?Eg
mGal B
642
640
638
B'
Antigonish Thrust Fault
metres B
JR-3
AP-1-74
AP-1
ECHI
ECB
ECAD
halite
anhydrite
H-D
DC
0 1 2 3 4 5 km

For legend, and location see Figs. 6-6, 6-10, 6-13

Figure 6-12. Bouguer gravity and geological profiles, James River deposit.

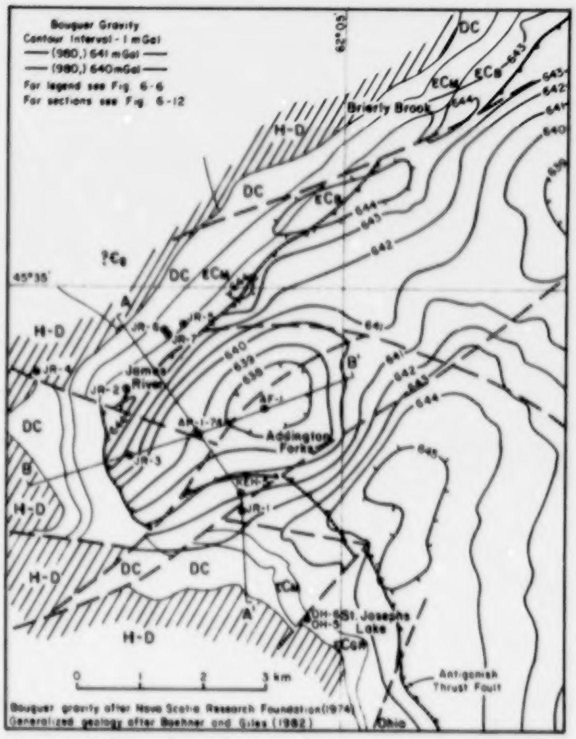
The deposit requires further exploration drilling and chemical analyses to determine its economic significance.

MABOU DEPOSIT

The Mabou deposit (NTS 11K/03) is located approximately 7 km southwest of Mabou and 6 km northeast of Port Hood near the community of Southwest Mabou, Inverness County, Cape Breton Island (Figs. 1-10 and 6-14).

The area is easily accessible through a series of paved and unpaved roads connected with Route 19 that runs from Port Hastings on the Strait of Canso through Port Hood to Inverness and the Cabot Trail on the western shore of Cape Breton Island. The Canadian National Railway line between Port Hastings and Inverness passes through Southwest Mabou.

The terrain in the area, underlain by Windsor Group and younger rocks, is characterized by rolling hills with elevations rising up to 125 m. The area to the east is underlain by Horton Group and older rocks and the terrain has more relief with elevations of 200 m and locally exceeding 250 m. Local relief is high near the valleys of the Mabou, East Mabou, Southeast Mabou and Mull Rivers and locally along the Northumberland Strait shoreline. To the north of Mabou Harbour, the Mabou Highlands, underlain by granitic and volcanic rocks, rise abruptly to a flat topped area where elevations exceed 300 m.


Bouguer Gravity
Contour Interval - 1 mGal
(980,) 641 mGal
(980,) 640 mGal
For legend see Fig. 6-6
For sections see Fig. 6-12
62°05'
45°35'
DC
ECM
ECB
H-D
Brierly Brook
?Eg
James River
Addington Forks
St. Josephs Lake
Antigonish Thrust Fault
Ohio
JR-1
JR-2
JR-3
JR-4
AP-1
AP-1-74
A
A'
B
B'
0 1 2 3 km

Bouguer gravity after Nova Scotia Research Foundation (1974)
Generalized geology after Boehner and Giles (1982)

Figure 6-13. Bouguer gravity and general geological map, James River deposit.

HISTORICAL BACKGROUND

The western part of Cape Breton Island has been the object of petroleum exploration since the mid 1850's. One of the first attempts in Nova Scotia to obtain petroleum in commercial quantities was reportedly undertaken by Pioneer Oil and Salt Company near Lake Ainslie in 1864 (Norman, 1932a).

How (1869) reported that salt derived from springs was made by the early Scottish settlers in the Judique area. The Mabou area was investigated by Hayes (1931) for its potash potential as part of a regional potash assessment. Hayes (1931) reported the occurrence of several brine seeps in the bed of Glendyer Brook approximately 1.2 km upstream from Glendyer Railway Station. These seeps occur in a limestone unit assigned to the Upper Windsor. This salt spring was sampled by Norman and analyses were made and reported by Cole (in Hayes, 1931).

The geology of the area was described and mapped by Norman (1935). He reported that early attention to the possibility of commercial

Table 6-2. Chemical analyses of salt samples from AP-1-74, James River deposit*

Sample Depth (feet)	% CaO	% Na_2O	% K_2O	% MgO	% Water Insoluble	% NaCl (Calculated from Na)
1382	0.76	38.0	1.0	0.02	Nil	72
1393	0.80	30.0	0.8	0.90	20.3	56
1494	0.90	35.0	0.3	0.25	6.7	66
1510	1.04	32.0	1.0	2.51	12.6	61
1530	1.05	37.0	0.4	1.10	2.4	70
1541	0.20	36.0	0.27	0.25	4.8	68
1599	1.2	36.0	0.5	0.06	3.4	68
1634	0.44	37.0	0.3	0.05	3.6	70
1681	1.20	36.0	0.4	0.35	3.9	68
1721	1.28	38.0	0.5	1.0	Nil	72
1816	0.56	36.0	1.0	0.30	4.7	68
1916	0.44	36.0	0.5	0.06	4.6	68
1936	0.69	36.0	6.25	0.60	Nil	68
1956	0.80	38.0	0.25	0.01	Nil	72
1986	0.92	38.0	0.25	0.06	Nil	72

*Stewart (1976)

petroleum deposits was attracted by the occurrence of oil seepages on the western side of Lake Ainslie, at McIsaac Point and at Ainslie Point. In 1926 and 1927 Gulf Oil Company drilled a series of shallow core holes totalling 1017 m (3335 ft.) (Mather and Trask, 1929) to determine the nature of the structure at Southwest Mabou. Windsor Group evaporites were intersected, but salt was not reported. The results were apparently not sufficiently encouraging to warrant further, deeper testing for petroleum.

In the early 1940's geological surveys were undertaken in the area by the Cape Breton Petroleum Company (Whitehead, 1941). A seismic survey by Heiland Exploration Company was undertaken near Southwest Mabou in 1942. Encouraged by the areas potential for petroleum, Lion Oil Refining Company of Eldorado, Arkansas acquired an interest in the tracts leased to Cape Breton Petroleum Company and in 1944 began boring Mac No. 1 near Southwest Mabou (MacNeil, 1944b). This hole reached a total depth of 1700.5 m (5579 ft.). A salt zone was intersected at approximately 425 m (1395 ft.) and was not completely penetrated. Further geological and geophysical surveys supervised by MacNeil were undertaken at the same time as the drilling was in progress. A second hole, Mary No. 1, was drilled approximately 975 m (3200 ft.) northwest of Mac No. 1. Salt was first intersected at 1366 and the hole was abandoned in a gypsum bed at 2093.7 m (6869 ft.).

In the late 1950's Imperial Oil Limited obtained a petroleum exploration licence in the Mabou area. Several geological and geophysical surveys including seismic, gravity and preliminary stratigraphic test drilling, were undertaken. In 1959 Imperial Oil Limited drilled Mabou No. 1 (MacEachren, 1959). This well, abandoned in Horton Group strata at 1568.2 m (5145 ft.), encountered small amounts of salt near the base of the Windsor Group at approximately 732 m (2400 ft.).

In early 1960 Imperial Oil Limited drilled a second hole, Port Hood No. 1, (MacEachren, 1960). Salt was first intersected at 1859.3-2255.5 m (6100-7400 ft.). Massive salt with some shale and locally thick beds of anhydrite were encountered to a depth of 2950 m (9680 ft.) and the well was abandoned at 2999.2 m (9840 ft.).

GEOLOGY

The stratigraphy and structure in the Mabou area has been described in published and unpublished reports by Bell (1926), Mather and Trask (1929), Norman (1932a and b, 1935), Whitehead (1941, 1943), MacNeil (1944a, b and c, 1945a and b), Stacey (1953), Murray (1960), Belt (1962), and Kelley (1967b). The stratigraphic nomenclature and subdivision is rather complex and varies from worker to worker. An outline of the general Carboniferous stratigraphic section was presented at the beginning of the Antigonish-Mabou area section. Discussion of the stratigraphy and structure in the area of the Mabou deposit will focus mainly on the Windsor Group while other strata will be described in general terms.

The most comprehensive published report on the geology in the immediate vicinity of the

Mabou deposit (Fig. 6-14) was by Norman (1935). He recognized rocks that range in age from Precambrian to Upper Carboniferous. The Precambrian, George River Group composed of metamorphosed quartzite and intrusions of granodiorite, diorite, sheared diorite and granite, occur as a massif block forming the Mabou Highlands to the north of Mabou Harbour. A Paleozoic-Precambrain unit was also mapped on the western side of the Mabou Highlands. These rocks composed of rhyolite, andesite, tuff, volcanic breccia, red shale, sandstone, conglomerate and diabase were considered by Kelley (1967b) and Kelley and MacKasey (1965) to be basal Mississippian, Fisset Brook Formation.

The Fisset Brook Formation is in turn overlain conformably by the Lower Carboniferous Horton Group. Norman (1935) indicated a total thickness of approximately 1800 m (6000 ft.) of sandstone, shale and conglomerate. Detailed examinations of the Horton Group stratigraphy have been made by Murray (1960) and by Kelley (1967b). Kelley (1967b) revised and extended the stratigraphic nomenclature of Murray (1960). The continental clastic Horton Group is succeeded conformably to unconformably by the mixed marine and continental Windsor Group, which comprises red shale, gypsum, anhydrite, halite and fossiliferous limestone. The stratigraphy of the Windsor Group has been studied in the area by Norman (1935) and Stacey (1953). Due to structural complications, the details of the stratigraphy of the whole section were not determinable, although sections on Port Hood Island gave relatively complete exposure of the Upper Windsor and part of the B Subzone (Fig. 6-4) and exposures in the Mabou Mines section represent the lower part of the A Subzone and the Horton-Windsor contact.

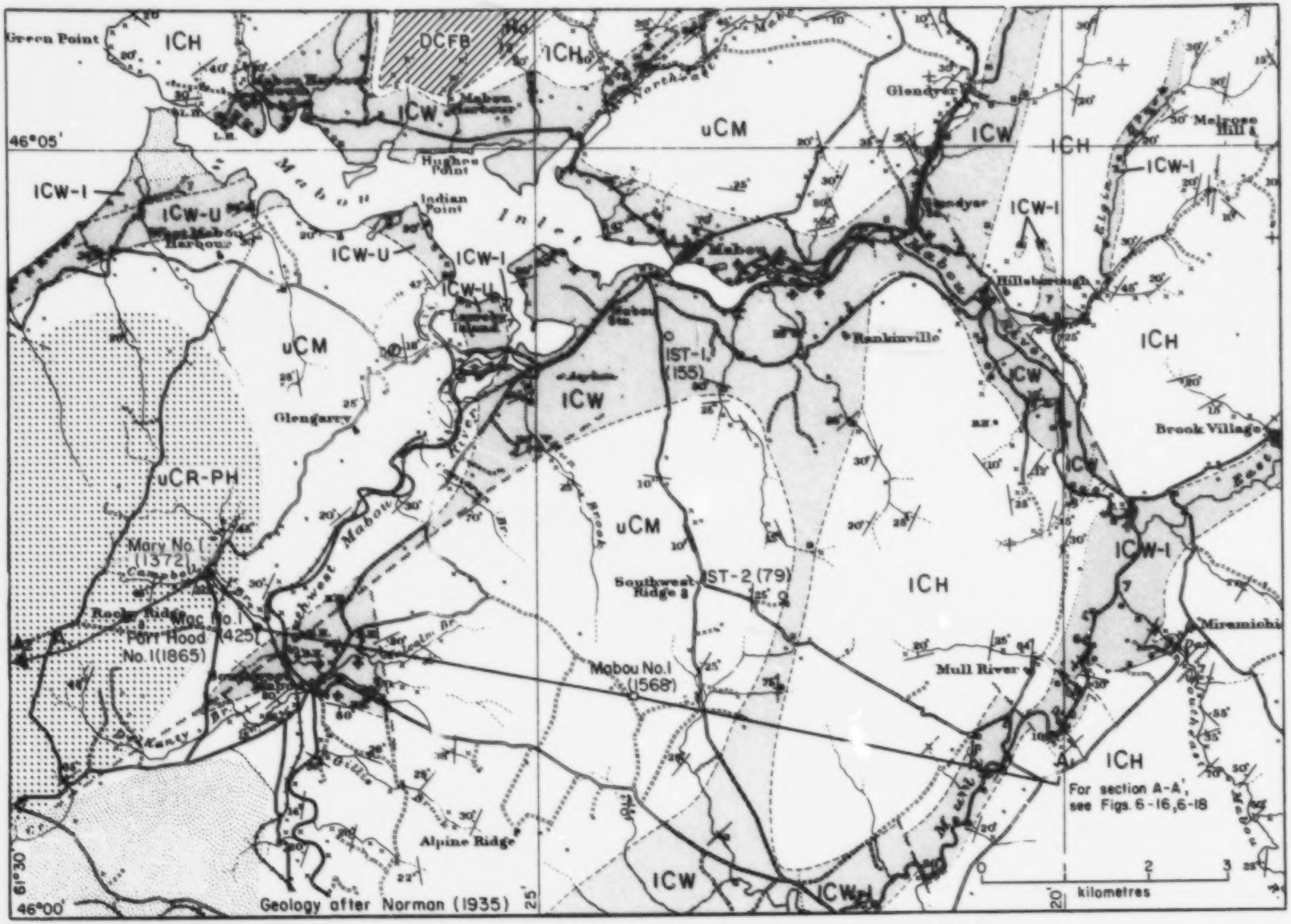
Norman (1935) considered the thick gypsum-anhydrite bed at Mabou Mines to be equivalent, in part, to the gypsum unit in the lowest part of the Port Hood Island section. Boehner and Giles (1982) indicated that the majority, if not all, of the severely deformed gypsum section is part of the Addington Formation (B Subzone) based on the presence of thin fossiliferous limestone units (Fig. 6-4). In the area of Mabou Harbour North, Norman (1935) reported a section similar to the Mabou Mines Section (Bridgeville Formation).

The section encountered near the bottom of Port Hood No. 1 (Fig. 6-15) appears to be the basal Windsor Group, lower sulphate and basal limestone overlying the Horton Group (Mabou Mines section).

The stratigraphic position of the major salt in the Mabou area is inferred to be located above the thick lower massive gypsum-anhydrite and basal laminated limestone units of the A Subzone. The salt in the Mabou drilling appears (although the data available are inconclusive) to be overlain by an intercalated gypsum, limestone, siltstone section interpreted to be equivalent to the B Subzone (Addington Formation). This section which is dominated by evaporites is in turn overlain by the intercalated red shale and limestone units of the Upper Windsor (Hood Island Formation). In the Port Hood No. 1 borehole salt was reported to occur as veins impregnating brecciated shale and limestone sections (Fig. 6-15). The extent and details of this breccia zone are not discernible in the uncored intervals, but the mixing of shale, limestone and salt in cuttings sampled indicates it probably occupies an extensive halo surrounding a deformed salt mass. It is probable that isoclinal folding of the section has accompanied salt impregnation, fragmentation and dislocation of relatively competent blocks. In the Mabou No. 1 borehole (Fig. 6-16), the salt is not abundant, and the section is thinner and incomplete because of faulting.

Lion Oil, Mac No. 1 (MacNeil, 1944a, b, and c) was drilled closest to the Windsor Group outcrop area near the core of the Southwest Mabou structure (Figs. 6-14, 6-15, and 6-16). The first indications of the salt zone were encountered at 425 m (1395 ft.). The hole was stopped in salt at 1700.5 m (5579 ft.). Lion Oil, Mary No. 1 (1944) was drilled approximately 975 m north-northwest of Mac No. 1. The salt zone was first encountered at 1366 m (4480 ft.). A massive gypsum bed was intersected at 2065.5 m (6780 ft.) and the hole was stopped in gypsum at 2093.7 m (6869 ft.). In 1960 Imperial Oil, Port Hood No. 1, was drilled near Rocky Ridge, approximately 1.8 km west-northwest of Mac No. 1. Salt was encountered at a still greater depth in this hole and was first reported as a vein halo in fractured rocks at a depth of approximately 1859.3 to 2255.5 m (6100 to 7400 ft.). Salt was intersected to 2944.4 m (9660 ft.). Sections of anhydrite and then laminated limestone were intersected to 2982 m (9783 ft.) where the Horton Group was intersected. The hole was abandoned in Horton at 2999.2 m (9840 ft.). Imperial Oil Mabou No. 1 was drilled near Southwest Ridge in 1959 (Cote and Hill, 1960), approximately 5 km east of Lion Oil, Mac No. 1. This hole is believed to have penetrated Mabou Formation to approximately 195 m (640 ft.) where Windsor Group rock types were first reported. The first indications of salt were reported at 688.8 m (2260 ft.). The salt was described in the cored intervals as orange halite in brecciated grey shale. The base of the Windsor Group with a thin anhydrite overlying a laminated limestone was indicated at 745.2 m (2445 ft.) where the Horton Group was intersected. The hole was abandoned in Horton Group strata at 1568.2 m (5145 ft.). Since the salt in this hole occurs only as veins in brecciated shales it is inferred to have been tectonically squeezed out.

The Windsor Group in the area is overlain with apparent conformity by a section of strata called the Mabou Formation by Norman (1935). The Mabou Formation (part of the Canso Group) comprises approximately 915 m (3000 ft.) of red sandstone and shale interbedded with grey sandstone and shale, and minor thin limestone beds. The lower contact with the uppermost Upper Windsor limestone unit, (the E_1 or Schizodus) is not exposed on Port Hood Island, although Norman (1935) reported that the uppermost Windsor


Green Point
ICH
DCFB
ICH
ICW
Mabou Harbour
46°05'
uCM
Glendyer
ICW
ICH
Melrose Hill
ICW-I
ICW-I
Hughes Point
Indian Point
Mabou Inlet
ICW-U
Port Mabou Harbour
ICW-U
ICW-I
ICW-U
ICW-I
Mabou
Hillsborough
Rankinville
ICH
uCM
Glengarry
IST-1 (155)
ICW
uCR-PH
Brook Village
uCM
Southwest Mabou River
ICW-I
Mary No.1 (1372)
Campbell
Southwest Ridge
IST-2 (79)
ICH
Rocky Ridge
Mac No.1 (425)
Port Hood No.1 (1865)
Miramichi
Mabou No.1 (1568)
Mull River
A
A'
ICH
For section A-A', see Figs. 6-16, 6-18
Alpine Ridge
ICW
ICW-I
61°30'
46°00'
25'
20'
0
1
2
3
kilometres

Geology after Norman (1935)

Figure 6-14. Geology in the vicinity of the Mabou deposit, Inverness County.

LEGEND

UPPER CARBONIFEROUS

	RIVERSDALE GROUP
uCR-PH	*PORT HOOD FORMATION:* sandstone, shale, and minor coal
	CANSO and/or RIVERSDALE GROUP(S)
uCM	*MABOU FORMATION:* sandstone, siltstone and shale

LOWER CARBONIFEROUS

	WINDSOR GROUP
lCW-U	Upper: sandstone, shale, gypsum, limestone
lCW-L	Lower: gypsum, sandstone, shale, limestone
lCW	Undivided: sandstone, shale, gypsum, limestone
	HORTON GROUP
lCH	Undivided sandstone, conglomerate and shale

DEVONO-CARBONIFEROUS

DCFB	*FISSET BROOK FORMATION:* basalt, rhyolite, tuff, conglomerate and sandstone

HADRYNIAN?

Hd	Sheared diorite?

SYMBOLS

Heavily drift-covered area	⁙
Rock outcrop, area of outcrop	x ⁙
Limestone or dolomite outcrop (Faribault-Fletcher maps)	////
Gypsum outcrop	▭▭ #
Geological boundary (defined, approximate, assumed)	——— – – – - - -
Bedding, tops known (inclined, vertical, overturned, horizontal)	⟋ ⟋ ⟋ +
Bedding, tops unknown (inclined)	⟋
Schistosity (inclined, vertical, dip unknown)	⟋ ⟋ ⟋
Gneissosity (inclined, vertical)	⟋ ⟋
Plunge of minor fold	↗
Drag fold (arrow indicates plunge)	~
Fault (defined, approximate, assumed)	〰 〰 ~ ~
Fault (solid circle indicates downthrow side)	〰•
Joint (inclined, vertical)	⟋ ⟋
Anticline (defined, approximate, arrow indicates direction of plunge)	—+— – →
Syncline (defined, approximate, arrow indicates direction of plunge)	—+— – →
Fossil locality	Ⓕ
Spore sample	Ⓢ
Glacial striae (ice flow direction known)	↙
Gravel deposit	⚒
Quarry	⚒
Diamond-drill hole	DDH•
Borehole	BH•
Sinkhole	SH•
Salt spring	⊕
Observed karst topography	∘∘∘
Drillhole intersecting salt; number (depth to salt, metres)	● IP-1(520)
Drillhole without salt; number (Total depth, metres)	○ SR6-1(277)
Drillhole location precise to 150 m	*

MINERALS

Anhydrite	ah	Limestone	lst
Gypsum	gyp	Pyrite	py
Lead	Pb	Zinc	Zn
Celestite	Sr		

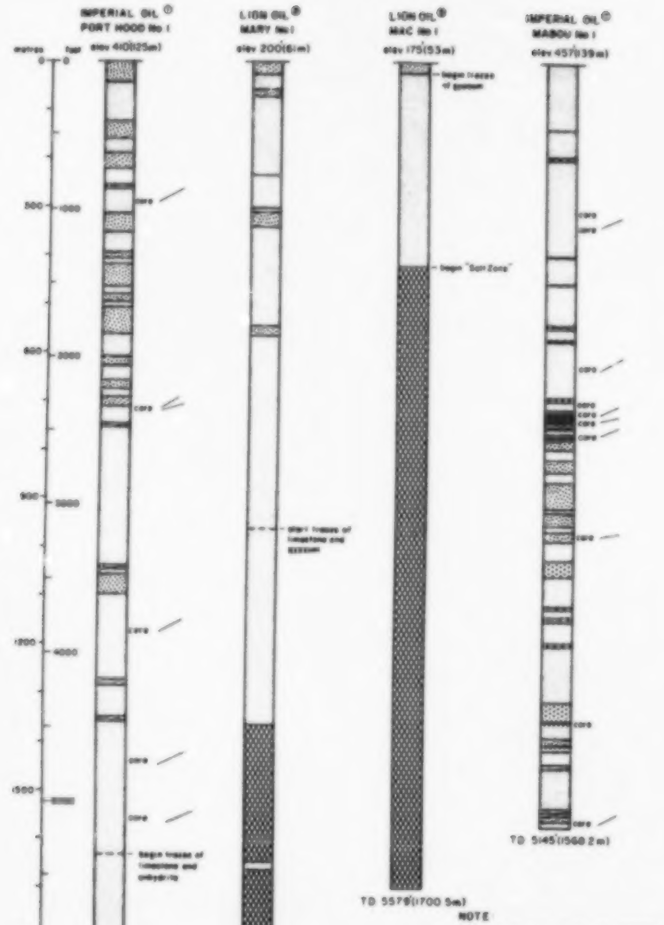
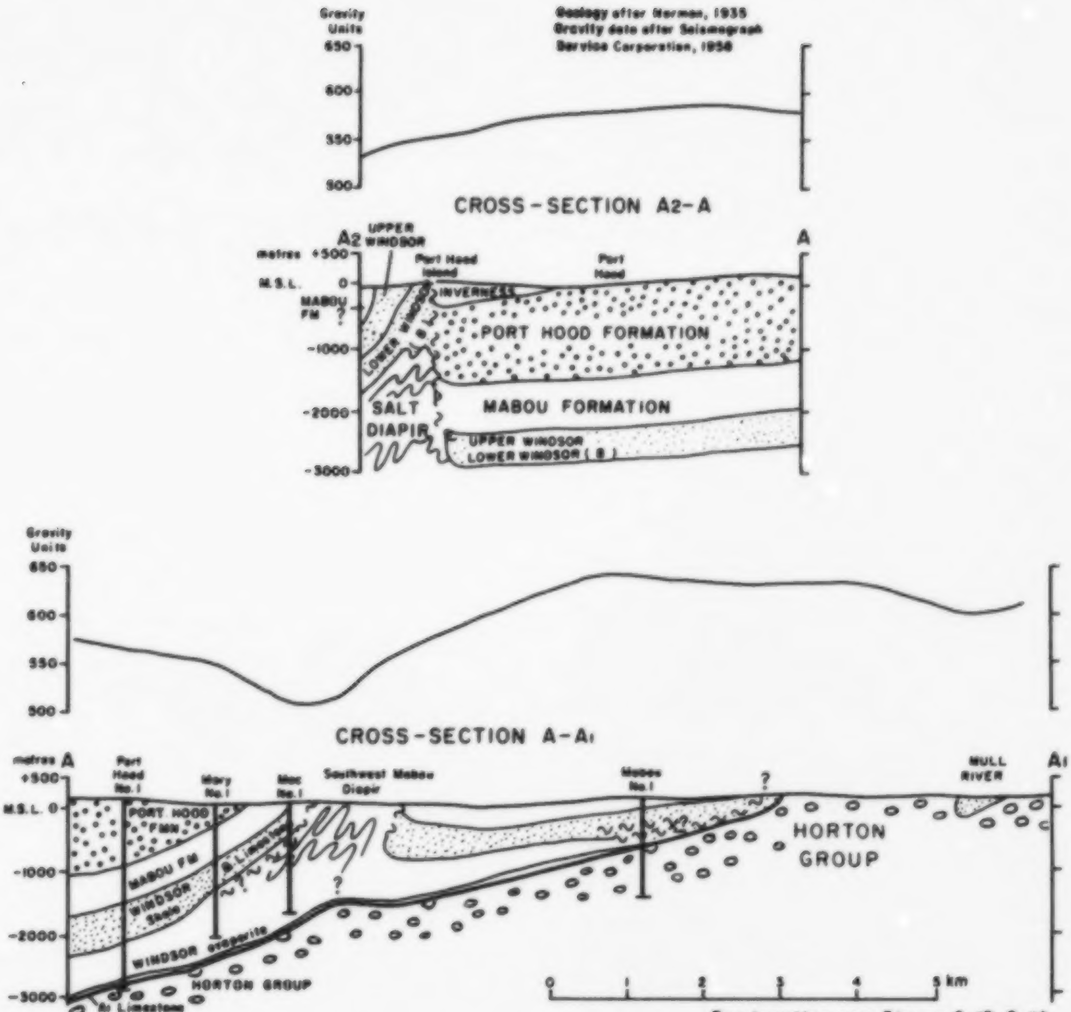

IMPERIAL OIL ①
PORT HOOD No 1
elev 410'(125m)
LION OIL ②
MARY No 1
elev 200'(61m)
LION OIL ②
MAC No 1
elev 175'(53m)
IMPERIAL OIL ①
MABOU No 1
elev 457'(139m)
metres
feet
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
core
intermixed
begin traces of limestone and anhydrite
start traces of limestone and gypsum
begin traces of gypsum
begin "Salt Zone"
TD 9840'(2999.2m)
TD 6869'(2093.7m)
TD 5579'(1700.5m)
TD 5145'(1568.2m)
NOTE
① Drill logs after Cote and Hill (1960)
② Drill logs after MacNeil (1944b)
LEGEND
Overburden
Shale
Shale and siltstone
Sandstone
Conglomerate and sandstone
Limestone and / or dolostone
No recovery (core or chips)
Gypsum and / or anhydrite
Rock salt (halite)
Nodular evaporite
Slate, metasandstone and various metasedimentary rock
Igneous intrusives, granite etc
Volcanics, basalt etc
Correlation uncertain ?
Brecciated
Bedding dips
Triconed, chips only

Figure 6-15. Drillhole profiles, Mabou deposit.


Gravity Units
650
600
550
500
CROSS-SECTION A2-A
A2
A
UPPER WINDSOR
metres +500
M.S.L. 0
Port Hood Island
Port Hood
MABOU FM ?
INVERNESS
LOWER WINDSOR
B.L.
PORT HOOD FORMATION
-1000
SALT DIAPIR
MABOU FORMATION
-2000
UPPER WINDSOR
LOWER WINDSOR (B)
-3000
Gravity Units
650
600
550
500
CROSS-SECTION A-A1
metres A
+500
M.S.L. 0
-1000
-2000
-3000
Port Hood No.1
Mary No.1
Mac No.1
Southwest Mabou Diapir
Mabou No.1
?
MULL RIVER
A1
PORT HOOD FMN
MABOU FM
B. Limestone
WINDSOR Shale
WINDSOR evaporite
HORTON GROUP
A1 Limestone
HORTON GROUP
0
1
2
3
4
5 km

Geology after Norman, 1935
Gravity data after Seismograph Service Corporation, 1958

For location see Figure 6-18, 6-14

Figure 6-16. Gravity and geological cross-sections, Mabou deposit, Inverness County.

Group beds lacking on Port Hood Island are exposed at Ragged Point south of Port Hood. Here Norman (1935) reported 107 m (350 ft.) of "Windsor Group" red shale with three thin gypsum beds at the contact zone between the E_1 limestone and the base of the Mabou Formation. He further indicated that the contact between the Windsor Group and younger strata ranges from conformable to unconformable. The disconformable relationship, according to Norman (1935), indicates gentle folding and erosion of the Windsor Group prior to the deposition of the Mabou Formation. The Mabou Formation has been preserved in the following three synclinal outcrop areas: in the western part of the map area between Southwest Mabou and West Mabou Harbour; in the eastern part between Alpine Ridge and Southwest Ridge; and north of Mabou Harbour near Glendyer. The Mabou-Port Hood Formation contact is transitional. The Port Hood Formation comprises approximately 1220 m (4000 ft.) of grey arkosic sandstone alternating with red shale, interbedded sandstone, and shale with some coal seams. The Port Hood Formation occurs in a major synclinal structure west of Port Hood No. 1 (Fig. 6-14) and is overlain by the Inverness Formation (Riversdale Group) which consists of approximately 700 m (2300 ft.) of grey sandstone, arkose, conglomerate, and grey shale with intercalated coal seams. The Inverness and Broad Cove Formations apparently overlap older strata and occur, for the most part, in a series of fault blocks along the western coast of Cape Breton.

The Carboniferous rocks in the Mabou area occur in a series of synclines and anticlines defined by Upper Carboniferous strata, including the Mabou, Inverness and Port Hood Formations. The Lower Carboniferous Horton Group occurs peripheral to the pre-Carboniferous basement rocks in the Mabou Highlands to the north and the Creignish Hills to the southeast. The Horton Group is present in a major anticline to the west and is inferred to underlie the remainder of the Carboniferous depositional area. The major fold structures trend generally northeast-southwest and plunge gently to the southwest. The entire sequence is crossed by a series of faults with major and minor displacement. Although Norman (1935) indicated that in most instances the faults were not well defined, he mapped an easterly dipping reverse fault on the eastern side of the Inverness coalfield. He estimated the displacement of this fault to exceed 914 m (3000 ft.).

A major northeasterly trending fault zone through Southwest Mabou coincides with the outcrop belt of Windsor Group. The Windsor Group is indicated to be overturned and dipping 70° south on Allan Brook approximately 4 km northeast of Southwest Mabou. Abundant gypsum outcrops were mapped in the Southwest Mabou area by Norman (1935) indicating Windsor Group is probably present in the area. This structure was described as an anticline by Norman (1935), but drilling and interpretations by Lion Oil Refining Company and Imperial Oil Limited indicate a more complex diapiric structure (Fig. 6-17). This situation is probably similar to those described in the Cumberland area where the structures were initially believed to have been simple anticlines, with little thickening expected in the evaporites of the Windsor Group. Subsequent drilling, however, has demonstrated extreme thickening, plastic deformation and diapiric intrusion probably as a result of tectonism.

The structural configuration of the rocks in the Southwest Mabou area has been described and interpreted (Fig. 6-17) by several previous workers including MacNeil and Whitehead (in Stacey, 1953), MacNeil (1945a and b), Bell (1958) and Roliff (1961). MacNeil (1945a and b) and MacNeil and Whitehead (in Stacey, 1953) portrayed the structure as an anticlinal diapir with a moderate angle reverse or thrust fault to the southeast. They believed the soft, plastic, incompetent Windsor Group rocks were squeezed between two relatively competent sandstone sections, the Horton Group below and the Canso-Riversdale above. The Horton was believed to have been folded into a relatively simple anticline. In contrast, the mobile Windsor Group behaved as an incompetent, partially intrusive mass. The siltstone, shale, limestone, and gypsum of the Upper Windsor, overlying the massive salt, were highly fractured brecciated and impregnated by veins of halite. This feature is apparent from the borehole lithologic chip logs and core logs and is similar to that encountered in the Cumberland area structures. This brecciation is probably most severe adjacent to the active core of the diapir such as in Mary No. 1, Mac No. 1, and to a lesser degree, Port Hood No. 1. Flowage to the evaporite core probably occurred away from the adjacent synclines and generally towards the axial area. It is suspected that the Windsor Group section in Mabou No. 1 represents a severely brecciated and attenuated section from which the salt has moved by shearing and flowage into the Southwest Mabou area to the west. This feature may also have been developed east of the structure, but has been subsequently removed by erosion. The Port Hood Island structure (Fig. 6-16) is interpreted to be a salt-cored, faulted anticline although drill data are not available to support the inferred presence of the salt core.

GEOPHYSICS

One of the earliest seismograph surveys in Atlantic Canada was undertaken in the Southwest Mabou area by Heiland Exploration Company of Shreveport, Louisiana (1942) for Cape Breton Petroleum Company. This survey covered several lines between Southwest Mabou and Mabou Harbour. In 1944 a gravity survey was undertaken by Robert H. Ray, Inc. (1944) for Lion Oil Refining Company. This survey, with stations at approximately 0.5 mile intervals, covered a large portion of western Cape Breton Island between Judique and Margaree.

The Inverness and Mabou areas were covered by a gravity meter survey using one quarter mile spacing by Seismograph Service Corporation (1958) for Imperial Oil Limited. This survey is presented as a simplified Bouguer gravity contour map in Figure 6-18.

In 1959 The Nova Scotia Research Foundation (1959b) surveyed several reflection seismic profiles in the Mabou area near Mabou Station and Southwest Ridge.

GEOCHEMISTRY

The occurrence of brine springs on Glendyer Brook is reported by Norman (1935). Cole (1930a) analyzed a brine sample (Table 6-3) collected by Norman who described its location as follows:

> The spring sampled flows out of a brown limestone 30 feet thick, where it crosses Glendyer Brook 3000 feet upstream from Glendyer Station, Inverness County, a station on The Inverness Railroad, and about 1000 feet downstream from old Glendyer Mills. The limestone belongs to the Upper Windsor series. The beds are massive though cut by joint-planes, while certain irregular layers are porous.

The chemistry of the Glendyer spring is typical of many NaCl springs with low $CaSO_4$ content which is associated with the dissolution of Windsor Group evaporites.

Salt in the Mabou deposit has only been analyzed in one section from Imperial Port Hood No. 1. A total of 26 samples from the interval 2100 m to 3249 m (6890-10660 ft.) were analyzed by Smith (1960) and the results are presented in Table 6-4. The bromine and potassium contents of this salt are low indicating brine concentrations were probably too low to reach saturation in potash.

In 1966 the bromine geochemistry of salt deposits in Nova Scotia was studied by Baar

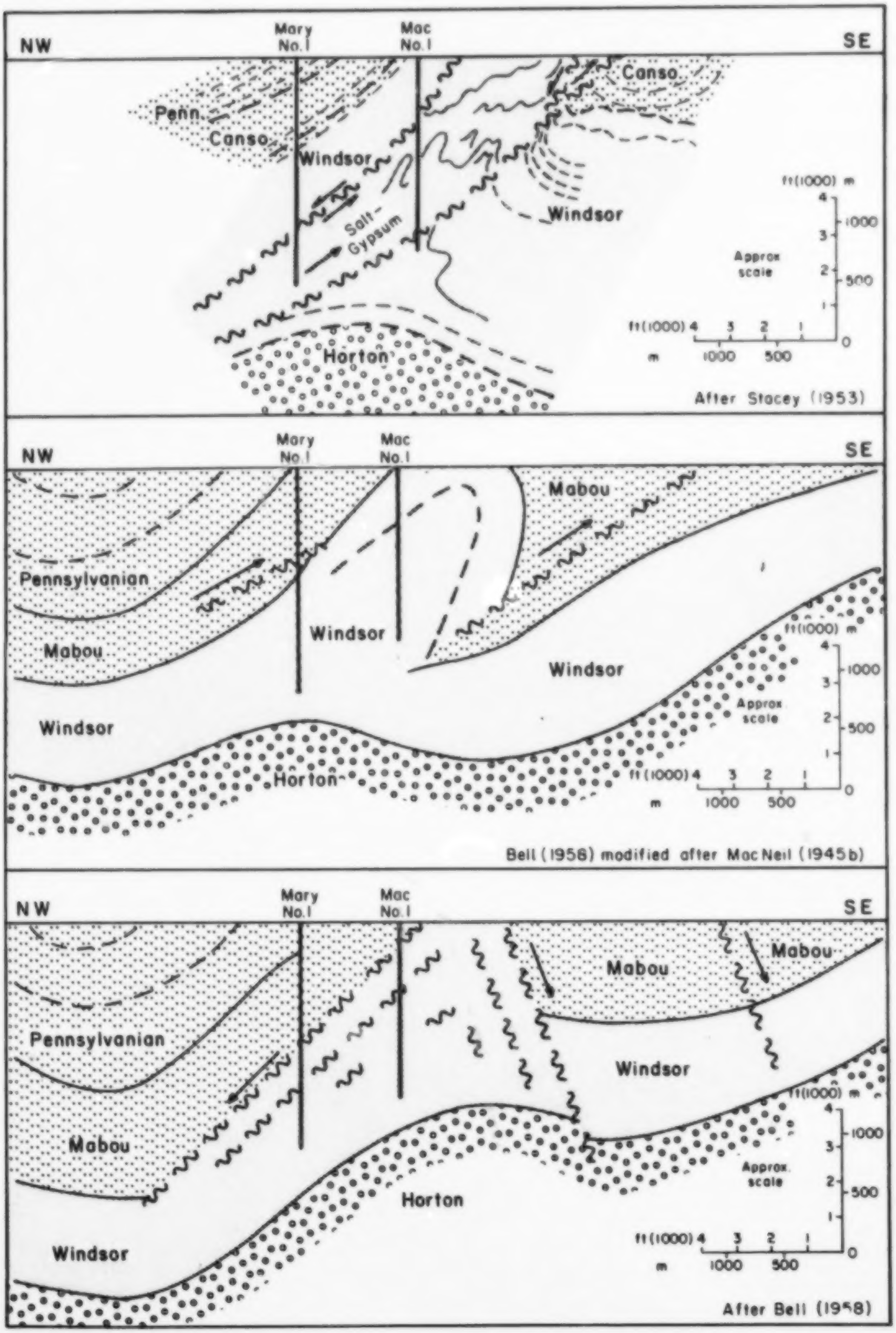

NW
Mary No. 1
Mac No. 1
SE
Penn.
Canso
Windsor
Canso
Salt-Gypsum
Windsor
Horton
ft(1000) m
4
3
2
1
0
1000
500
Approx scale
ft(1000) 4 3 2 1
m 1000 500
After Stacey (1953)
NW
Mary No. 1
Mac No. 1
SE
Mabou
Pennsylvanian
Mabou
Windsor
Windsor
Windsor
Horton
Approx scale
Bell (1958) modified after MacNeil (1945b)
NW
Mary No. 1
Mac No. 1
SE
Mabou
Mabou
Pennsylvanian
Windsor
Mabou
Horton
Windsor
Approx scale
After Bell (1958)

Figure 6-17. Schematic cross-sections of the Mabou deposit.

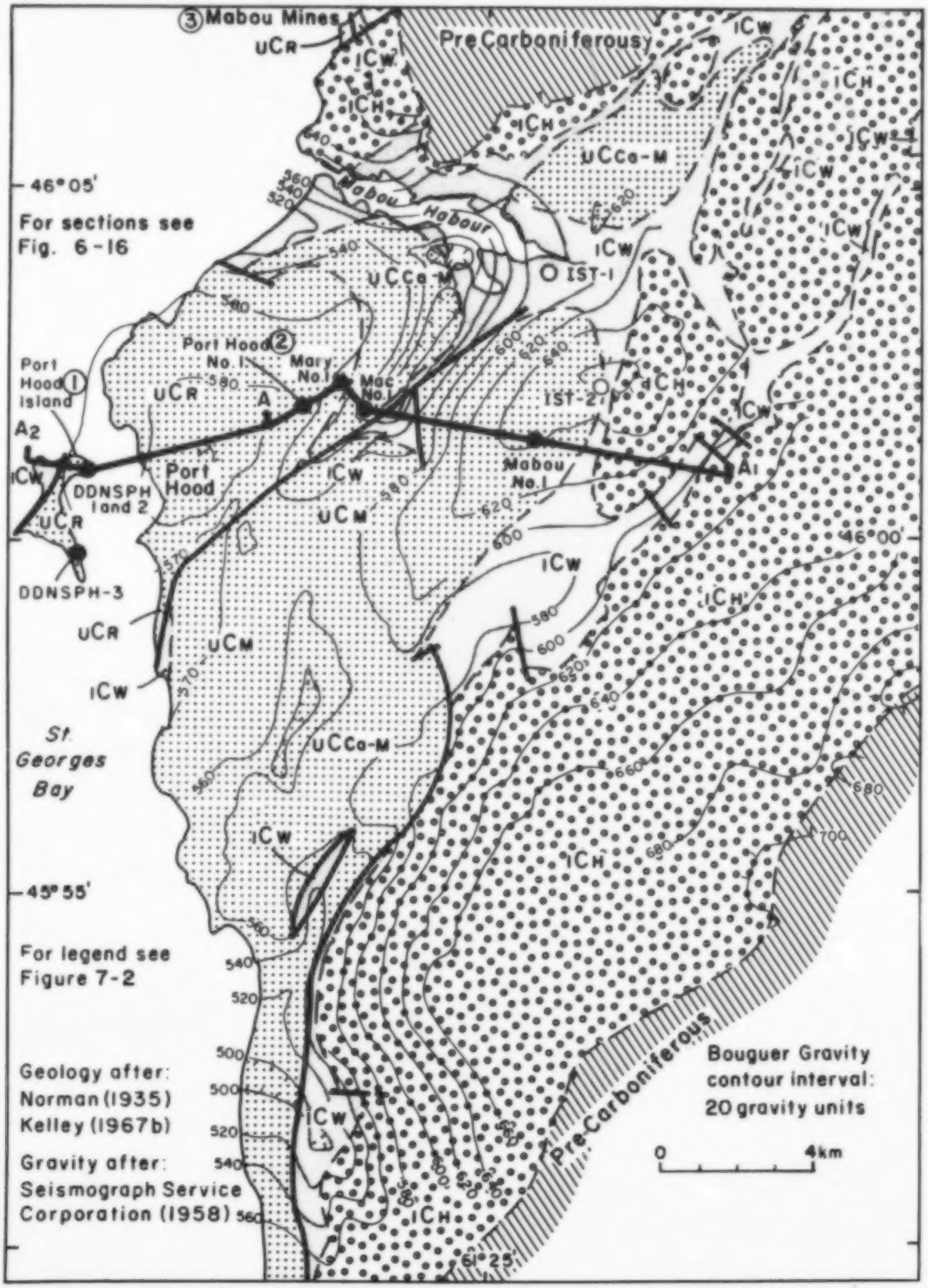

③ Mabou Mines
uCR
Pre Carboniferous
lCw
lCH
uCCa-M
46°05'
For sections see
Fig. 6-16
Mabou Habour
IST-1
uCCa-M
Port Hood ②
No. 1
Mary
No. 1
Mac
No. 1
Port
Hood ①
Island
uCR
A
A2
lCw
DDNSPH
1 and 2
Port
Hood
uCR
DDNSPH-3
IST-2
dCH
Mabou
No. 1
A1
uCM
46°00'
uCR
uCM
lCw
St.
Georges
Bay
uCCa-M
lCw
lCH
45°55'
For legend see
Figure 7-2
Geology after:
Norman (1935)
Kelley (1967b)
Gravity after:
Seismograph Service
Corporation (1958)
Pre Carboniferous
Bouguer Gravity
contour interval:
20 gravity units
0
4km
61°25'
500
520
540
560
570
580
600
620
640
660
680
700

Figure 6-18. Bouguer gravity and general geology, Mabou area, Inverness County.

(1966) as part of the 1966 Potash Project. Baar analyzed core samples from Imperial Oil Port Hood No. 1 and cutting samples from Port Hood No. 1 and Lion Oil Mary No. 1. These results are presented in Table 6-5. The bromine and potassium analyses indicate low brine concentrations.

Table 6-3. Analyses of Glendyer spring, Mabou deposit, Inverness County*

Sample No.	**38**
FIELD NOTES AT TIME OF SAMPLING	
Temperature of atmosphere, °F	n.d.
Temperature of brine, °F	n.d.
Baume degrees	n.d.
Equivalent specific gravity	-
LABORATORY NOTES	
Specific gravity at 60°F	1.023
Total solids at 110°C	3.25
Reaction	N
ANALYSES OF SOLIDS	
Na ....Per cent	34.77
K ....Per cent	0.06
Ca ....Per cent	2.04
Mg ....Per cent	0.19
SO_4 ....Per cent	4.23
Cl ....Per cent	54.62
Br ....Per cent	none
I ....Per cent	none
Totals	95.91
HYPOTHETICAL COMBINATION	
$CaSO_4$ ....Per cent	5.99
$CaCl_2$ ....Per cent	0.78
$MgSO_4$ ....Per cent	-
$MgCl_2$ ....Per cent	0.65
K_2SO_4 ....Per cent	-
KCl ....Per cent	0.11
Na_2SO_4 ....Per cent	-
NaCl ....Per cent	88.38
Totals	95.01

*Cole (1930a)

ECONOMIC CONSIDERATIONS

Potash has not been reported in the Mabou salt deposit. The salt occurs at depths ranging from 425 to 2900 m with maximum thickness exceeding 1500 m. Details about the quality of the various salt horizons are unknown. The salt may occur in a structurally complex situation analogous to some of the salt intrusions in the Cumberland area. A substantial Bouguer gravity anomaly is coincident with the deposit area. Salt springs indicative of subsurface dissolution of salt are not common in the area. The deposit is situated close to railway and highway transportation, but is located approximately 10 km inland from potential tide water shipping sites. The deposit requires further exploration drilling to determine its quality, distribution and economic importance.

OHIO OCCURRENCE

The Ohio occurrence (NTS 11E/09 and 11E/08) is situated in the western part of the Antigonish Basin near Ohio and is approximately 7 km south of the James River deposit (Figs. 1-10 and 6-19). St. Joseph is located approximately 11 km north and Cross Roads Ohio 3 km south of the Ohio occurrence.

The area is readily accessible through a series of paved and unpaved roads connected with the Trans-Canada Highway 104 and Route 7.

The terrain in the area is typical of the Carboniferous Antigonish Lowlands with gently rolling hills and elevations rarely exceeding 125 m. Immediately west of the area however elevations rise abruptly to 240 m in the Antigonish Highlands.

HISTORICAL BACKGROUND

The Antigonish Basin was investigated for its potash potential by Pohl as part of a regional survey by Hayes (1931). Many salt springs and seeps were located, but none were found in the area of the Ohio occurrence. Springs were described however, in the Salt Springs area 9 km to the northeast and near Dunmore 8 km east. No further exploration for salt and potash was carried out until 1966 when Kenneco Exploration (Canada) Ltd. drilled several gravity anomalies (Grace, 1966). A gravity low indicative of salt was not defined in the Ohio area. Since the exploration activity in the Ohio area has been focused mainly on base metal mineralization including copper, lead and zinc. These deposits are associated with the basal part of the Windsor Group where it onlaps the pre-Carboniferous basement rocks of the Antigonish Highlands.

Exploration drilling for base metals was undertaken in the Ohio area by Kenneco Exploration (Canada) Ltd. (Grace, 1966) and more recently by Imperial Oil Ltd. (Burton, 1974) and Cuvier Mines Ltd. (Black, 1979). Salt was intersected in drillhole AN-AH-1 drilled in a base metal exploration survey by Cuvier Mines Ltd. near Ohio (Black, 1979).

GEOLOGY

The geology in the vicinity of the Ohio occurrence was described and mapped by Benson (1974), Boehner (1980b) and most recently by Boehner and Giles (1982). The Windsor Group in this area (Fig. 6-19) is indicated to occur in an onlap relationship with pre-Carboniferous basement. This relationship has been established in exploration drillholes by Kenneco Exploration (KEH-2) and Imperial Oil (OH-1 and OH-4) in which fossiliferous basal Windsor Group limestone (Gays River Formation of Giles et al. (1979)) directly overlies pre-Carboniferous felsic volcanic rocks. The stratigraphy of the Windsor Group rocks above this basal limestone is unclear due to the scarcity of outcrop and drillhole information in the area. Remnants of Bridgeville Formation gypsum and anhydrite occur locally. Outcrop patterns are disrupted by the reworked paraconglomerate of the Lakevale Formation and by the Antigonish Thrust Fault.

Table 6-4. Chemical analyses, drill cuttings Port Hood No. 1*.

Depth in feet	Wt. % Soluble	Cl as Wt. % NaCl	Br as Wt. % NaBr	I as Wt. % NaI	K as Wt. % KCl
6890 - 6920	68.2	67.2	Nil	Nil	0.057
7050 - 7060	47.9	46.2	Nil	Nil	0.014
7240 - 7280	59.6	57.1	Nil	Nil	0.011
7420 - 7440	85.7	82.4	Nil	Nil	trace
7450 - 7470	82.1	76.2	Nil	Nil	Nil
7730	68.7	67.4	trace	Nil	0.009
7800 - 7850	66.3	66.4	Nil	Nil	0.014
7850 - 7900	89.1	88.9	Nil	Nil	0.035
6900 - 7950	77.8	75.6	trace	Nil	Nil
7950 - 8000	75.2	73.9	Nil	Nil	0.047
8000 - 8050	84.0	81.5	Nil	Nil	0.047
8050 - 8100	84.4	82.0	Nil	Nil	0.034
8100 - 8150	81.3	77.9	0.028	Nil	0.039
8150 - 8190	71.2	68.1	Nil	Nil	0.019
8210 - 8220	90.1	89.0	Nil	Nil	0.049
8390 - 8400	39.9	38.2	Nil	Nil	0.006
8500 - 8510	61.3	57.7	Nil	Nil	0.030
8550 - 8580	64.7	61.1	Nil	Nil	0.037
8580 - 8610	73.4	72.1	trace	Nil	0.014
8710 - 8760	62.8	57.4	Nil	Nil	0.045
8760 - 8800	73.1	70.2	Nil	Nil	0.052
8800 - 8850	49.4	44.3	Nil	Nil	0.036
9040 - 9050	82.9	79.6	Nil	Nil	0.033
9120 - 9167	56.1	53.2	Nil	Nil	0.011
6280 - 6290	99.9	99.2	Nil	Nil	0.015
6650 - 6660	99.1	99.5	trace	Nil	0.037

*Smith (1960)

Table 6-5. Analyses of drill core samples, Port Hood No. 1 and cutting samples from Port Hood No. 1 and Lion Oil Mary No. 1.*

Depth in feet	% K	% Br	% NaCl	%Br/100%NaCl
6105	0.052	0.0031	99.1	0.0032
6111	0.080	0.0020	96.0	0.0021
6283	0.05	0.0027	100.0	0.0027
6284	0.025	0.0030	100.0	0.0030
6284A	0.025	0.0032	96.6	0.0032
6286	0.025	0.0037	99.6	0.0037
6288	0.035	0.0030	100.0	0.0030
6289	0.033	0.0034	100.0	0.0034
6291	0.047	0.0034	100.0	0.0034
6292	0.028	0.0035	99.6	0.0035
6640	0.031	0.0052	99.6	0.0052
6655	0.043	0.0085	96.5	0.0088
7002	0.043	0.0025	93.0	0.0027

Bromine Contents (wt. % Br/100% NaCl) of cutting samples

	Number of Samples	
Wt. % Br/100% NaCl	Port Hood No. 1(a)	Mary No. 1(b)
0.003 - 0.0039	-	11
0.004 - 0.0049	5	21
0.005 - 0.0059	3	4
0.006 - 0.0069	1	-

(a) Port Hood No. 1 between 7800 and 9420 feet
(b) Mary No. 1 between 5300 and 6800 feet

*Baar (1966)

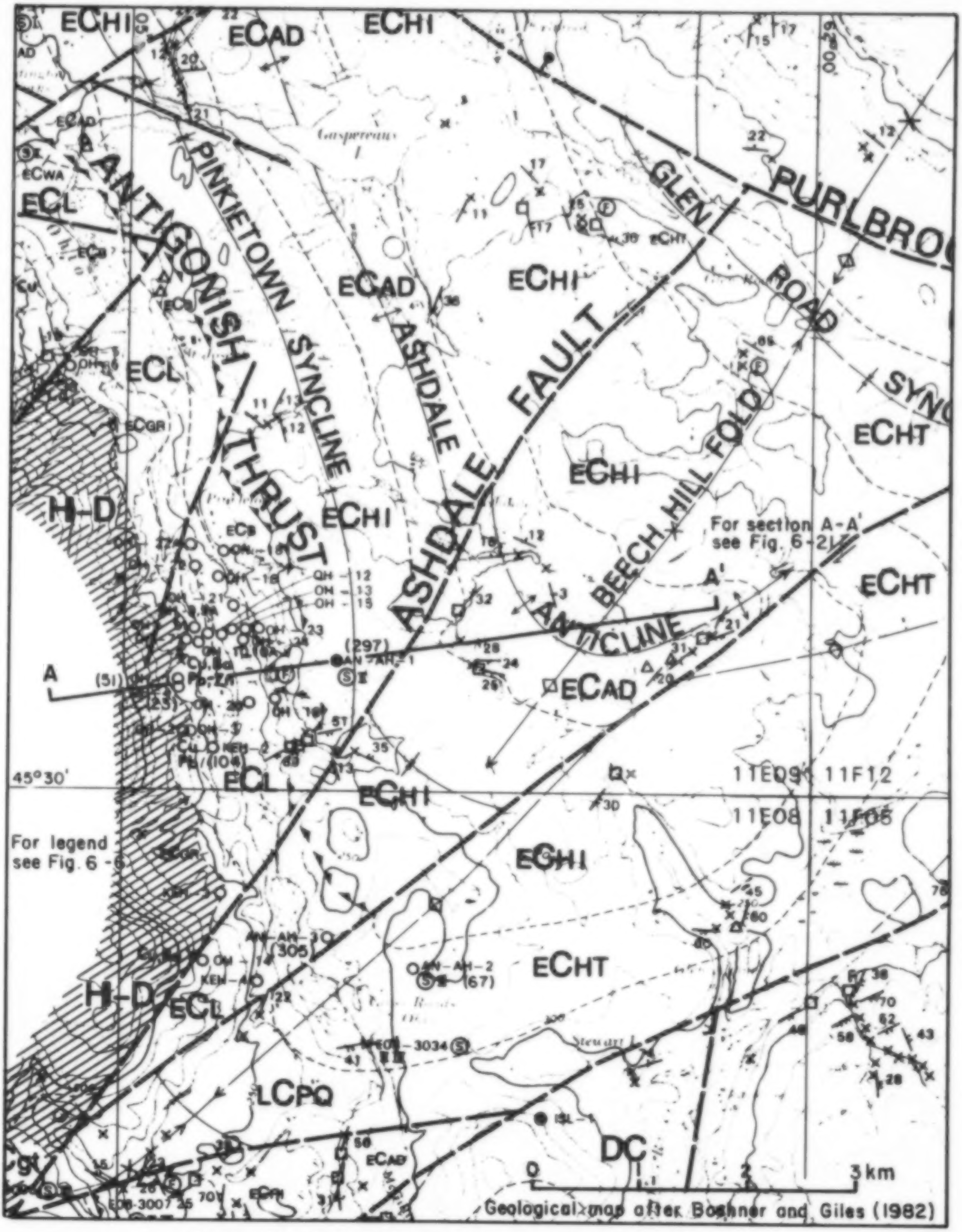

ANTIGONISH THRUST
PINKIETOWN SYNCLINE
ASHDALE
ASHDALE FAULT
GLEN ROAD SYNC
PURLBRO
BEECH HILL FOLD
ANTICLINE
ECHI
ECAD
ECL
ECHT
ECWA
ECGR
H-D
LCPQ
DC
A
A'
For section A-A' see Fig. 6-21
For legend see Fig. 6-6
45°30'
11E09 11F12
11E08 11F05
(297)
(305)
(67)
(104)
(51)
(23)
0 1 2 3 km
Geological map after Boehner and Giles (1982)

Figure 6-19. Geological map, Ohio occurrence, Antigonish County.

AN-AH-1, was drilled on the eastern side of the Ohio River approximately 1.5 km east of the erosional limit of the Windsor Group (Figs. 6-19, 6-20 and 6-21). Salt was intersected at a depth of 296.9-297.5 m (974-976 ft.). This thin bed is situated beneath 34.7 m (114 ft.) of massive anhydrite. It is not clear whether this bed is isolated in the anhydrite section or whether it is the start of an interbedded zone that might have been intersected if the hole had continued. Halite veins appear at a depth of 289 m (948 ft.), 7.9 m (26 ft.) above the top of the salt bed. The salt bed comprises pale orangeish medium grained halite with scattered grey-green siltstone inclusions. Bedding dips of the rocks in AN-AH-1 are generally moderate to gentle with an average of approximately 30°.

The stratigraphic assignment of the succession is not well defined at present. The following correlations are made on the basis of the work of Boehner (1980b) and Boehner and Giles (1982). The thick limestone near the top of the hole is correlated with the basal Upper Windsor limestone (Herbert River Limestone). The section beneath this major limestone is correlative with the middle part of the Windsor Group (Addington Formation) which is characterized by interbedded gypsum-anhydrite, carbonate and redbeds. The boundary between this succession and the major salt-sulphate section which generally underlies it is not readily apparent. The thin salt bed lies very near the Antigonish Thrust Fault located at this boundary, but the present data are insufficient to indicate exactly which side it lies on. The salt at Ohio is assigned occurrence status until further data on the lateral extent and thickness are available.

GEOPHYSICS

The area in the vicinity of the Ohio occurrence is included on a 2 inch to 1 mile total gravity map prepared for the Nova Scotia Department of Trade and Industry by the Nova Scotia Research Foundation (1955). Drillhole AN-AH-1 (Black, 1979) was drilled on the southern end of an elongate gravity maximum that is centred approximately 1 km northeast of St. Joseph. The major Antigonish Basin gravity low centred in the vicinity of the Pomquet River occurrence extends westward as far as the Glen Road area situated 5 km east of AN-AH-1. The exact relationship between the total gravity anomalies and the distribution of salt is not clear.

The major portion of the Antigonish Basin is probably underlain by thick Windsor Group salt, however in most instances the depth to the Hartshorn Formation salt may exceed 1000 m because of the thick overlying section of Canso Group strata. These rocks underlie most of the central part of the Basin. The thick sedimentary succession in the central part of the basin is probably a major contributor to the gravity low. The presence of stratified salt in the Ohio area, which is intermediate to the central basin total gravity low and the basement rocks of the Antigonish Highlands (gravity high), is probably masked by regional gravity increases produced by the proximity of relatively dense pre-Carboniferous basement in the subsurface at Ohio. The proximity and influence of basement rocks is further indicated by magnetometer surveys in the area.

GEOCHEMISTRY

No analyses are available on the salt in AN-AH-1. The salt is probably quite pure, but this is of little importance in such a thin intersection. Salt springs have not been reported in the immediate area indicating that if salt is present in significant quantities then it is probably well sealed against circulating groundwater.

ECONOMIC CONSIDERATIONS

The Ohio occurrence is a thin (60 cm) bed of halite in anhydrite that is of no economic significance if it is an isolated occurrence. The presence of salt may suggest the presence of a major stratified salt deposit possibly at greater depth. Further drilling would be necessary to determine if additional salt of economic importance is present.

POMQUET RIVER OCCURRENCE

The Pomquet River occurrence (NTS 11F/12) is situated approximately 3 km southwest of Pomquet Forks and 4 km northeast of St. Andrews near the Pomquet River, Antigonish County, Nova Scotia (Figs. 1-10 and 6-22).

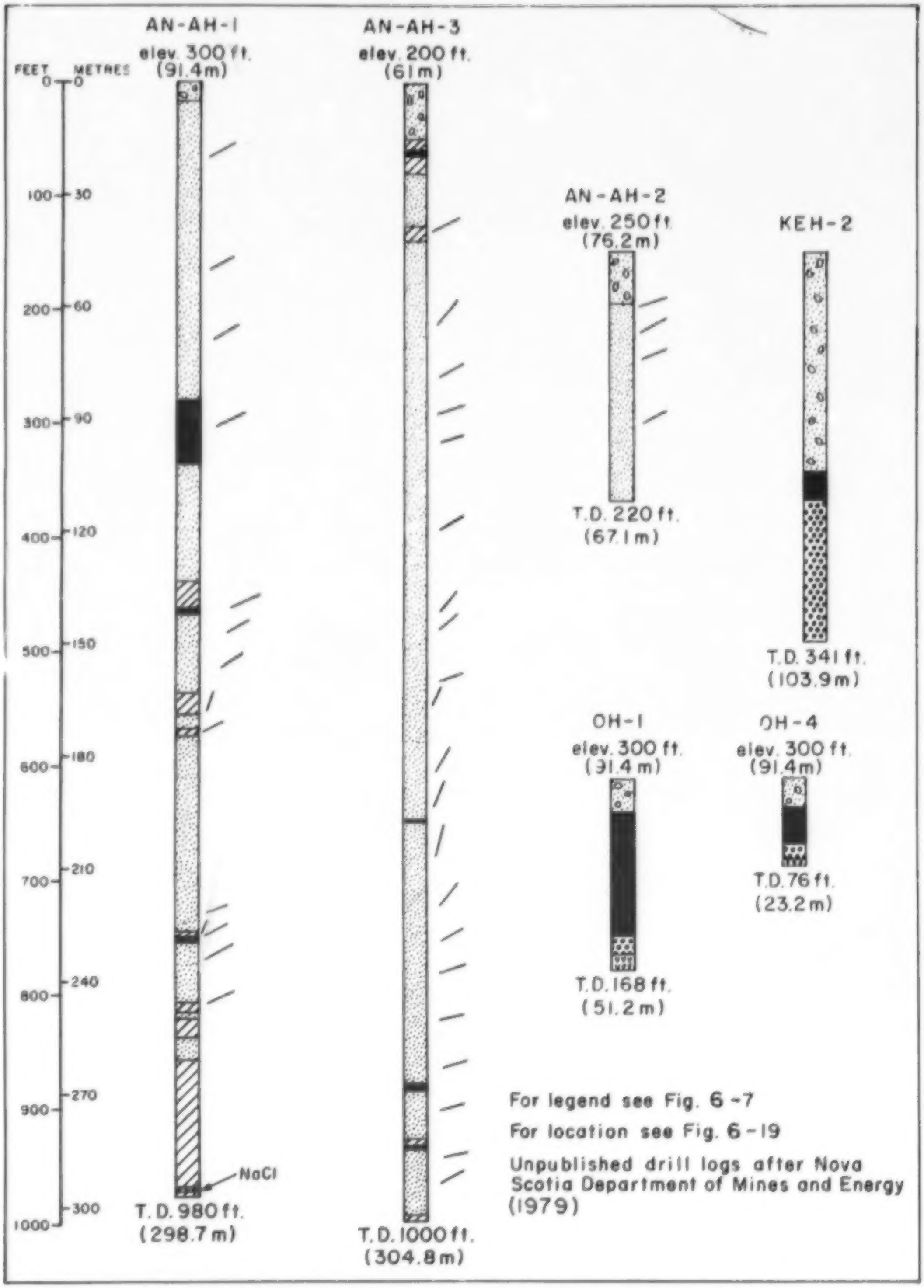
The area is easily reached by a series of paved and unpaved roads connected with the Trans-Canada Highway 104 that runs east from Antigonish through Pomquet Forks to Port Hastings on the Strait of Canso. The mainline of the Canadian National Railway crosses the Pomquet River approximately 1.5 km north of Pomquet Forks.

The occurrence is located in the Carboniferous Antigonish Lowlands which typically has gently rolling terrain with elevations generally less than 75 m, but which locally reach up to 125 m in the west and 175 m in the south and east.

HISTORICAL BACKGROUND

Fletcher (1887) indicated salt springs and ponds were found associated with gypsum in several areas. The Pomquet area was investigated by Pohl as part of the "Antigonish Basin" area in a regional potash assessment compiled by Hayes (1931). Two salt springs were located by Pohl in the immediate vicinity of the Pomquet River occurrence. Several other salt springs were also located in the St. Andrews-Dunmore-Pinedale area approximately 6 km southwest of the Pomquet springs (Fig. 6-22). The major salt springs were sampled and analyzed by Cole (1930a).

Windsor Group rocks in the vicinity of the Pomquet River occurrence are as described and mapped by Sage (1954). The Pomquet River area was drilled for petroleum by Lura Corporation Limited in 1958. Two diamond-drill holes, NSDM 2554 (K-1) and NSDM 2555 (K-2), were spudded near

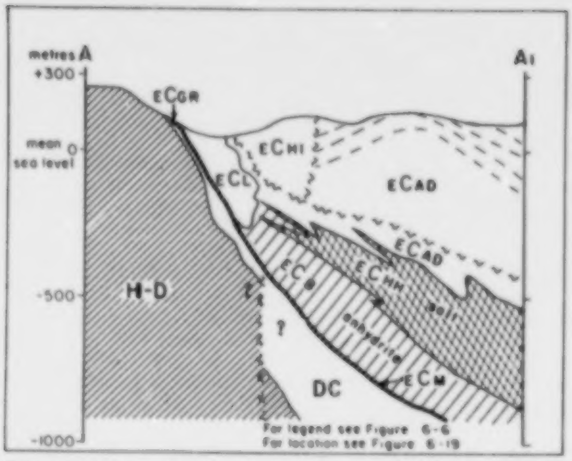

FEET
METRES
0
100
200
300
400
500
600
700
800
900
1000
30
60
90
120
150
180
210
240
270
300
AN-AH-1
elev. 300 ft.
(91.4m)
NaCl
T.D. 980 ft.
(298.7 m)
AN-AH-3
elev. 200 ft.
(61 m)
T.D. 1000 ft.
(304.8 m)
AN-AH-2
elev. 250 ft.
(76.2 m)
T.D. 220 ft.
(67.1 m)
KEH-2
T.D. 341 ft.
(103.9 m)
OH-1
elev. 300 ft.
(91.4 m)
T.D. 168 ft.
(51.2 m)
OH-4
elev. 300 ft.
(91.4m)
T.D. 76 ft.
(23.2 m)

For legend see Fig. 6-7

For location see Fig. 6-19

Unpublished drill logs after Nova Scotia Department of Mines and Energy (1979)

Figure 6-20. Drillhole profiles, Ohio occurrence, Antigonish County.



For legend see Figure 6-6
For location see Figure 6-19

Figure 6-21. Geological cross-section, Ohio occurrence.

a Bouguer gravity low approximately 3 km southwest of Pomquet Forks (MacNeil, 1959). A strong flow of brine was reported to have been encountered near the top of NSDM 2554 and a bed of salt near the bottom. NSDM 2555 was drilled approximately 500 m southeast of NSDM 2554, but was abandoned without encountering salt.

In 1966 Kenneco Explorations (Canada) Ltd. explored the Antigonish area for possible salt-sulphur-potash and base metal deposits (Grace, 1966). KEH-6 was drilled on the southern edge of the Pomquet River Bouguer gravity minimum approximately 2.5 km southeast of NSDM 2554. Small quantities of salt in veins were reported at a depth of 204 m (668 ft.) and the hole was abandoned at 372.5 m (1222 ft.).

GEOLOGY

The geology in the vicinity of the Pomquet River occurrence was mapped and described by Sage (1954) and Benson (1970). MacNeil (1959) compiled a geological map included in an unpublished report on petroleum exploration for Lura Corporation Limited in 1958. The most recent work is included in a report on the Carboniferous geology in the Antigonish Basin by Boehner (1980b) and Boehner and Giles (1982) (Figs. 6-1, 6-5 and 6-22).

Rocks assigned to an undivided Devono-Carboniferous unit, Windsor and Canso Groups are mapped in the immediate vicinity of the occurrence. The Devono-Carboniferous rocks occur in a broad area to the southeast and have a northeastly outcrop trend. In this area the Devono-Carboniferous comprises moderate to steeply dipping beds of greyish red sandstone, siltstone, mudstone and shale.

This package is overlain with apparent conformity or is in fault contact with folded (locally overturned) red siltstone and shale, limestone, gypsum, anhydrite and halite of the Windsor Group. Sage (1954) reported that although one half of the section exposed on the Pomquet River is overturned, it represents one of the most complete with respect to the number of limestone members present (Giles, 1980). The Windsor Group rocks outcropping in the occurrence area have been assigned to the Addington and Hood Island Formations. The major basal evaporite section is not exposed. Isolated fault blocks of Macumber Formation are present on the southern side of the Glenroy Fault. The Windsor Group is conformably overlain by Canso Group strata comprising medium grey and greyish red siltstone, and fine grained sandstone.

The Glenroy and Pomquet Harbour Faults are the major longitudinal high angle faults in the Pomquet River occurrence area (Fig. 6-22). Both have significant dip and strike slip displacement and the Glenroy defines the southern border of the Antigonish Basin. The McLellan Road and Pomquet Station Faults are transverse faults with possible listric geometry. They are inferred to be closely related to the Antigonish Thrust Fault at depth. Although poorly defined in outcrop, the major folds in the Windsor Group have steeply dipping overturned limbs and fold axes that are nearly perpendicular to the major northeasterly trending faults. The Meadow Green Syncline is the exception with its arcuate fold axis and gently dipping limbs. The faults in the area together with the overturned beds suggest rather complex structure. Several salt springs indicate that salt is present in the vicinity.

Petroleum exploration in this area was undertaken by Lura Corporation Limited in 1958 (MacNeil, 1959). Two holes, NSDM 2554 (K-1) and NSDM 2555 (K-2), were drilled near the centre of gravity low (Figs. 6-23 and 6-24). Neither hole encountered petroleum and only one, K-1 intersected salt from 363 to 379 m (1191-1242 ft.). K-1 was abandoned at 401 m. Both holes encountered drilling difficulties and unfortunately were prematurely abandoned.

In 1966 Kenneco Explorations (Canada) Limited drilled KEH-6 (Grace, 1966) near Meadow Green on the southeastern flank of the Pomquet River gravity low (Fig. 6-23). Minor salt as veins was encountered at 204 m and the hole was abandoned at 372.5 m. Boehner (1980b) indicated this drillhole intersected a vertical to overturned section of the E_1 Limestone (Fig. 6-4) and the basal Hastings Formation.

GEOPHYSICS

The Nova Scotia Research Foundation (1959c) prepared a geophysical compilation and interpretation for Lura Corporation from surveys undertaken between 1952 and 1958. This compilation delineated a gravity anomaly (total gravity low) centred between St. Andrews and Pomquet Forks (Fig. 6-24). In an interpretation of a profile across the anomaly a high angle reverse fault was postulated at the Horton-Windsor contact. The two Lura drillholes, K-1 and K-2, were drilled near the centre of the low and indicated that the cause of the anomaly (believed to be low density salt) must be at a depth in excess of 300 m. A thin bed of salt was encountered in drillhole K-1 at a depth of 363 m,

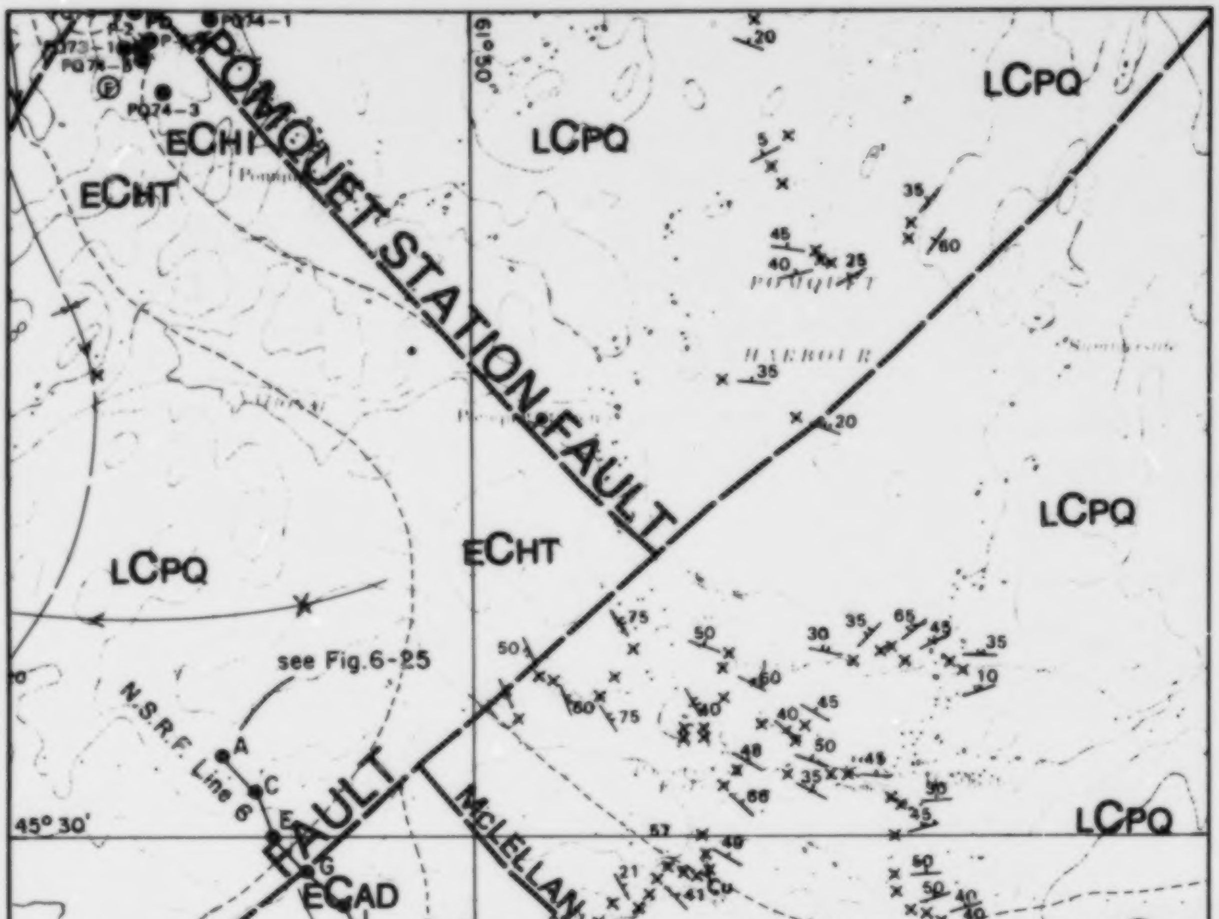

POMQUET STATION FAULT
LCPQ
ECHI
ECHT
ECHT
LCPQ
LCPQ
ECHT
LCPQ
see Fig.6-25
N.S.R.F. Line 6
A
C
E
G
I
K
M
FAULT
45° 30'
61° 50'
LCPQ
ECAD
ECHI
McLELLAN ROAD FAULT
ECHT
ECHT
(363)
NSDM 2554
NSDM 2555
(255)
ECAD
ECHI
ECHI
MEADOW GREEN SYNCLINE
ECHT
FAULT
DC
FAULT
ECHI
(372)
KEH-6
ECHI
ECM
Cu
GLENROY
DC
PQ74-1
PQ74-3
0
1
2
3 km
For legend, see Fig. 6-6
Geological map after Boehner and Giles (1982)

Figure 6-22. Geological map, Pomquet River occurrence, Antigonish County.

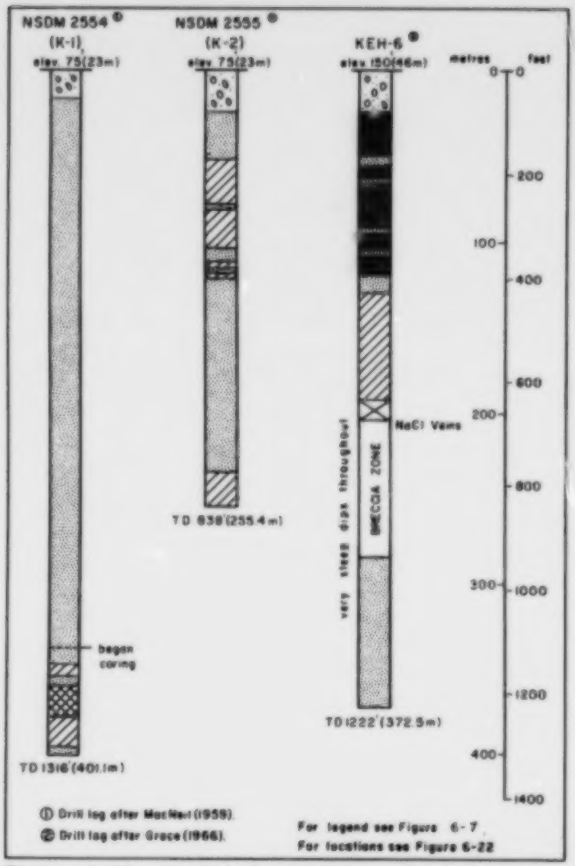

NSDM 2554 ①
(K-1)
elev. 75(23m)
NSDM 2555 ②
(K-2)
elev. 75(23m)
KEH-6 ②
elev. 150(46m)
metres
feet
0
0
200
100
400
600
200
800
300
1000
1200
400
1400
began coring
TD 1316'(401.1m)
TD 838'(255.4m)
NaCl Veins
BRECCIA ZONE
very steep dips throughout
TD 1222'(372.5m)
① Drill log after MacNeil (1959).
② Drill log after Grace (1966).
For legend see Figure 6-7
For locations see Figure 6-22

Figure 6-23. Drillhole profiles, Pomquet River occurrence, Antigonish County.

but the major salt mass inferred to have produced the anomaly was not reached.

A reflection seismic survey line profile was made by the Nova Scotia Research Foundation (1959c) for Lura Corporation Limited. The line (line 6) is located approximately 400 m east of NSDM 2554 (K-1), and has a trend of north-northwest (Figs. 6-22 and 6-25). Bedding (reflector) dips are fairly regular in the area northwest of shot point G which is an area inferred to be underlain by relatively undisturbed Canso Group. The area between shot points G and O is more complicated with an antiform structure indicated.

GEOCHEMISTRY

Pohl (in Hayes, 1931) reported the occurrence of two salt springs in the Pomquet River area and two in the Dunmore area. These springs were described, sampled, and analyzed by Cole (1930a), who reported the following:

> Pomquet River Spring (No. 23). This spring is located on the south side of the first crossroad joining the Antigonish-Mulgrave highway west of where this highway crosses the Pomquet River, and 1.2 miles south on the crossroad from the highway. The flow is not appreciable but the seepage keeps the pond full even in the driest weather. The pond is nowhere more than one foot deep, with a length of 50 feet and a breadth of 20 feet. The bottom is soft black muck and if disturbed has a strong hydrogen sulphide smell.

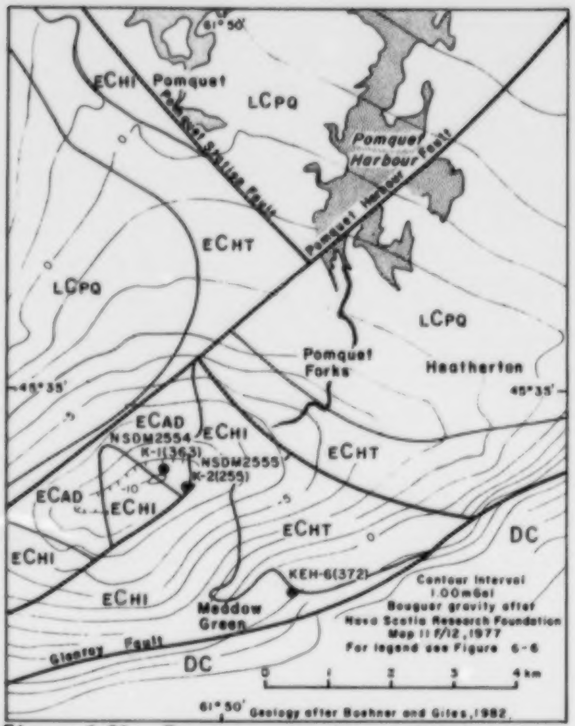

61°50'
ECHI
Pomquet
Pomquet Station Fault
LCPQ
Pomquet Harbour Fault
Pomquet Harbour Fault
ECHT
LCPQ
LCPQ
Pomquet Forks
Heatherton
45°35'
45°35'
ECAD
NSDM2554
K-1(363)
ECHI
NSDM2555
K-2(255)
-10
-5
ECHT
ECAD
ECHI
-5
ECHT
0
DC
ECHI
ECHI
KEH-6(372)
Meadow Green
Contour Interval 1.00mGal
Bouguer gravity after Nova Scotia Research Foundation Map 11 F/12, 1977
For legend see Figure 6-6
Glenroy Fault
DC
0
1
2
3
4 km
61°50'
Geology after Boehner and Giles, 1982.

Figure 6-24. Bouguer gravity anomaly and general geological map, Pomquet River occurrence, Antigonish County.

> Pomquet River Intervals Spring (No. 24). Another saline spring occurs in the meadow intervals through which Pomquet River flows, about 2 1/2 miles upstream from where the Antigonish-Mulgrave highway crosses the river. The actual spring area covers about 30 feet square and the brine is coming up through gravel together with occasional gas bubbles. The gravel is all iron stained and on a dry day there are salt encrustations on the pebbles. The flow is hard to estimate but is probably not more than 1/4 gallon per minute. A number of depressions in the meadow land resemble gypsum sink-holes and many of the larger ones are filled with water.

> Dunmore Spring (No. 25). One mile west of Dunmore, Antigonish County, a post office on the west bank of the South Antigonish River, at a point 5 miles south of its mouth, a number of saline pools occur in the flats on the south side of a small creek.

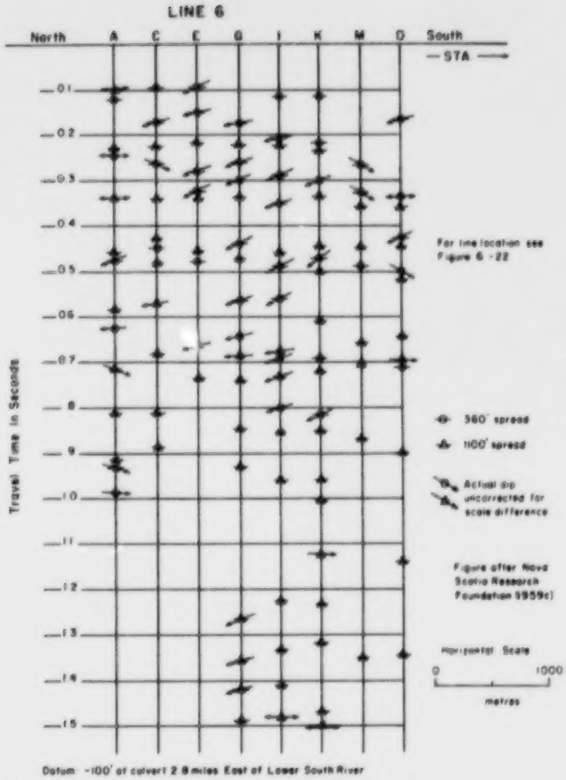


Figure 6-25. Reflection seismic survey, Line 6, Pomquet River occurrence, Antigonish County.

These springs have no appreciable flow and the salinity is low.

In addition Cole (1930a) reported analyses of the brines from the salt springs (Table 6-6). The springs have compositons typical of the many moderate $CaSO_4$ salt springs in Nova Scotia. Spring No. 23 is anomalous in its hypothetical content of $MgSO_4$ and Na_2SO_4. The salt springs in the Pomquet River occurrence area are probably related to faults and fractures connecting Windsor Group salt beds with circulating ground water.

ECONOMIC CONSIDERATIONS

The Windsor Group evaporite sequence in the area of the Pomquet River occurrence contains halite of unknown quality, thickness and distribution. Potash salts have not been reported. Salt was intersected at depths of 363-379 m in a drillhole located near the centre of a major Bouguer gravity low. Salt springs are common in the structurally complex area. This occurrence will require further exploration to determine its economic potential.

SOUTHSIDE HARBOUR DEPOSIT

The Southside Harbour deposit (NTS 11F/12) is located between Southside Antigonish Harbour and Pomquet approximately 10 km northeast of Antigonish, Antigonish County, Nova Scotia (Figs. 1-10 and 6-26).

The area is readily accessible from a series of paved and unpaved roads connected with the Trans-Canada Highway 104 that runs from Antigonish through Lower South River to Port Hawkesbury. Southside Antigonish Harbour is located approximately 7 km north of Lower South River. The mainline of the Canadian National Railway between Stellarton and Port Hawkesbury crosses Antigonish Harbour near South River Station approximately 5.8 km south of the deposit.

The deposit is located in the Antigonish Carboniferous Lowlands which are characterized by gently rolling terrain where elevations are generally less than 75 m though locally reach up to 125 m. In the higher land to the southeast, elevations of 175 m are encountered. In the immediate area of the deposit elevations are generally less than 50 m though locally, for example in areas to the west underlain by granite, elevations of 75 m are present.

HISTORICAL BACKGROUND

Fletcher (1887) described the history of a salt venture which was begun by Deacon of the Nova Scotia Salt Works and Exploration Company in 1866. Exploratory drilling began at Town Point approximately 1.5 km northwest of Southside Harbour on the northern shore of Antigonish Harbour, but salt was not encountered. The venture was more successful at Antigonish, but it too failed when the brine quantity and quality deteriorated and more could not be located.

The Antigonish Basin was assessed for its potash potential by Pohl as part of a regional project under Hayes (1931). Many salt springs were located in the area although none were described in the immediate vicinity of the Southside Harbour deposit.

In early 1951 the Nova Scotia Department of Trade and Industry engaged the firm Donald, Ross and Company of Montreal, to investigate the potential for establishing a soda ash industry in the Province. The project at Southside Harbour involved the Nova Scotia Research Foundation, the Nova Scotia Department of Mines (1952a) and MacNeil as consultant geologist. The Southside Harbour area was the primary target because a high grade limestone deposit was known to be present. Geological and geophysical surveys accompanied by a diamond-drilling exploration program in 1951 and 1952 outlined a salt deposit of indeterminate size near Southside Harbour.

In 1951 the Nova Scotia Department of Mines (1952a) drilled NSDM 1708, approximately 520 m east of the Southside Harbour road. Salt was first encountered at 237 m (779 ft.) and the hole was abandoned at 318.5 m (1045 ft.) (Fig. 6-27).

The Seismograph Service Corporation was employed to do a gravity and magnetic survey of the area in 1952 (Pohly, 1952a). In 1952 two other holes were drilled into a gravity minimum

Table 6-6. Analyses of salt springs, Pomquet River area, Antigonish County*.

Sample No.	23	24	25
FIELD NOTES AT TIME OF SAMPLING			
Temperature of atmosphere, °F	65	65	65
Temperature of brine, °F	64	51	62
Baume degrees	1.5	4.0	1.75
Equivalent specific gravity ..	1.010	1.027	1.012
LABORATORY NOTES			
Specific gravity at 60°F	1.0155	1.0300	1.0055
Total solids at 110°C	1.88	4.07	0.80
Reaction	N	N	N
ANALYSES OF SOLIDS			
Na ....Per cent	31.35	33.35	33.21
K ....Per cent	0.15	0.11	0.17
Ca ....Per cent	3.08	3.44	2.22
Mg ....Per cent	0.57	0.13	0.16
SO_4 ....Per cent	13.64	8.39	4.60
Cl ....Per cent	45.51	51.69	52.35
Br ....Per cent	n.d.	None	n.d.
I ....Per cent	n.d.	None	n.d.
Totals	94.30	97.11	92.71
HYPOTHETICAL COMBINATION			
$CaSO_4$ ....Per cent	10.47	11.70	6.52
$CaCl_2$ ....Per cent	-	-	0.83
$MgSO_4$ ....Per cent	2.82	0.16	-
$MgCl_2$ ....Per cent	-	0.27	0.62
K_2SO_4 ....Per cent	0.34	-	-
KCl ....Per cent	-	0.21	0.32
Na_2SO_4 ....Per cent	5.61	-	-
NaCl ....Per cent	75.03	84.77	84.40
Totals	94.30	97.11	92.69

*Cole (1930a)

located east of NSDM 1708. NSDM 1835 intersected salt at 231.6 m (760 ft.) and was abandoned at 356.6 m (1170 ft.). NSDM 1836 intersected salt at 232.8 m (764 ft.) and was stopped at 436.5 m (1432 ft.) (Fig. 6-27).

Lura Corporation Limited explored the Southside Harbour-Monks Head area for petroleum in 1958 after a small gas flow was encountered in NSDM 1836. A single drillhole, Lura No. 1 (NSDM 2671) (Shaw, 1969), was drilled near Monks Head near the axis of the Monks Head Anticline approximately 3 km northeast of NSDM 1708. Salt was not intersected and there were no petroleum showings.

In 1969 Novasel Limited drilled Novasel 1 (NSDM 4862) (Nova Scotia Department of Mines, 1970) approximately 1.3 km east-southeast of NSDM 1708. Salt was first intersected at 235 m (770 ft.) and the hole was abandoned at 356.6 m (1200 ft.). A small gas flow encountered in NSDM 1836, together with other factors, prompted the Brador Oil Company Limited to drill for petroleum in the Southside Harbour area. In 1976 Brador Anschutz Hole No. 1 was drilled immediately north of NSDM 1708 and 1836 (Farries Engineering Ltd; 1976). Salt was intersected between 250 and 460 m (820 and 1510 ft.).

GEOLOGY

The geology in the vicinity of the Southside Harbour deposit was described and mapped by Sage (1954), Benson (1970), Boehner (1980b) and Boehner and Giles (1982) (Fig. 6-1).

The oldest (Lower Paleozoic) rocks are found in an isolated block to the northwest of Antigonish Harbour. These rocks consist of faulted and folded grey green siltstone and argillite, greywacke, minor tuff, conglomerate and dark green andesite assigned to the Browns Mountain Group (Benson, 1970). A small granite body is indicated to have intruded the Browns Mountain Group.

These rocks are overlain with angular unconformity by rocks assigned to the Lower Carboniferous Horton Group which comprises interstratified conglomerate and sandstone.

The Horton Group is overlain conformably(?) by Windsor Group strata which comprise siltstone, shale, gypsum, anhydrite, halite, and limestone. The stratigraphy of the Windsor Group in the area was studied and described by Sage (1954) who concentrated mainly on the limestone units. The stratigraphic section was described by Sage

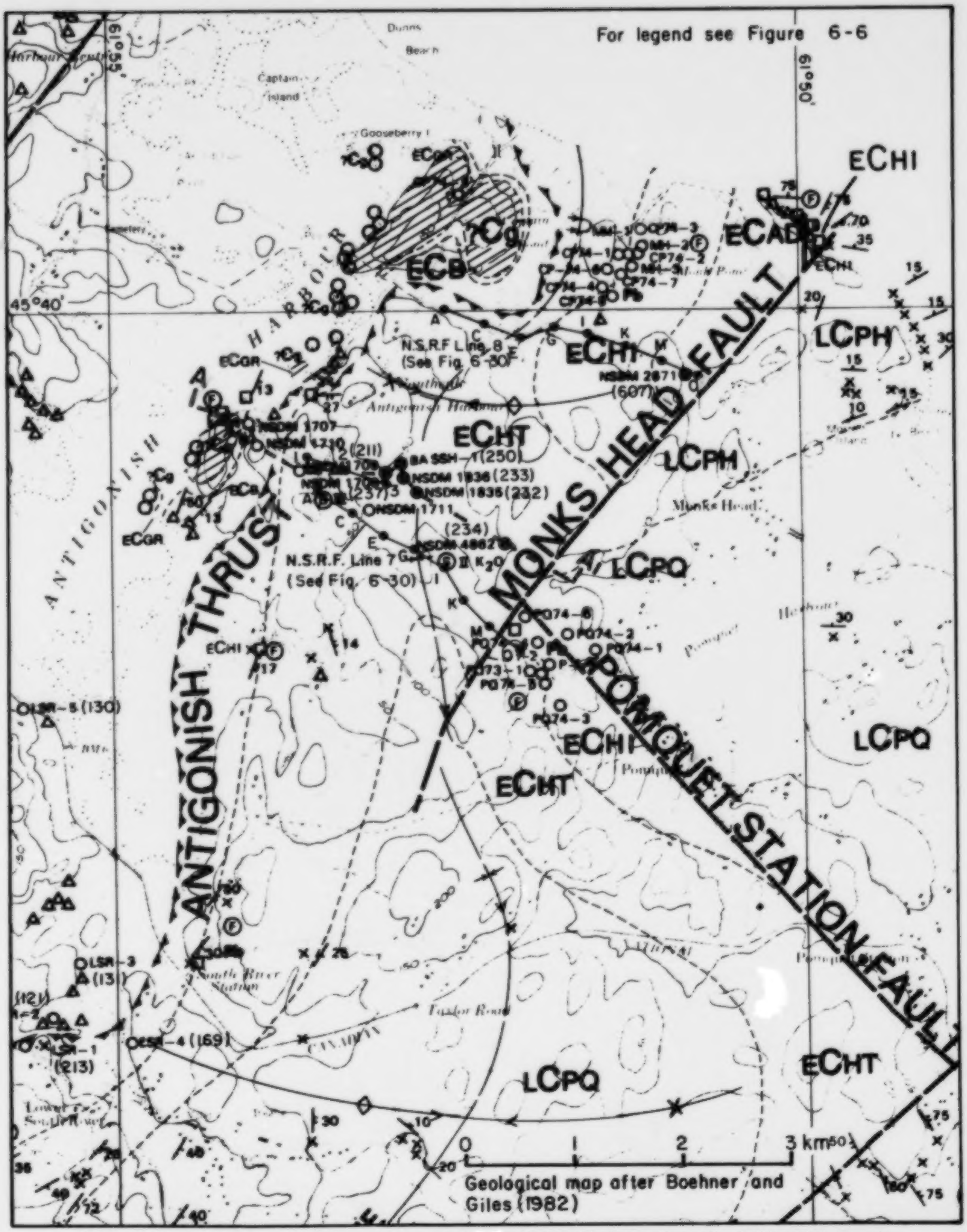

For legend see Figure 6-6
61°55'
61°50'
45°40'
Dunns Beach
Captain Island
Gooseberry I
ECHI
ECAD
ECB
ECGR
ECHT
LCPH
LCPQ
ECHI
ECHT
LCPQ
ECHT
LCPQ
ANTIGONISH HARBOUR
ANTIGONISH THRUST
MONKS HEAD FAULT
POMQUET STATION FAULT
N.S.R.F Line 8 (See Fig. 6-30)
N.S.R.F. Line 7 (See Fig. 6-30)
NSDM 2871 (607)
NSDM 1707
NSDM 1710
BA SSH-1 (250)
NSDM 1836 (233)
NSDM 1835 (232)
NSDM 1711
(234)
NSDM 4862
Monks Head
Pomquet
LSR-5 (130)
LSR-3 (131)
LSR-4 (169)
(121)
LSR-1 (213)
South River Station
Taylor Road
0 1 2 3 km
Geological map after Boehner and Giles (1982)

Figure 6-26. Geology in the vicinity of the Southside Harbour deposit, Antigonish County.

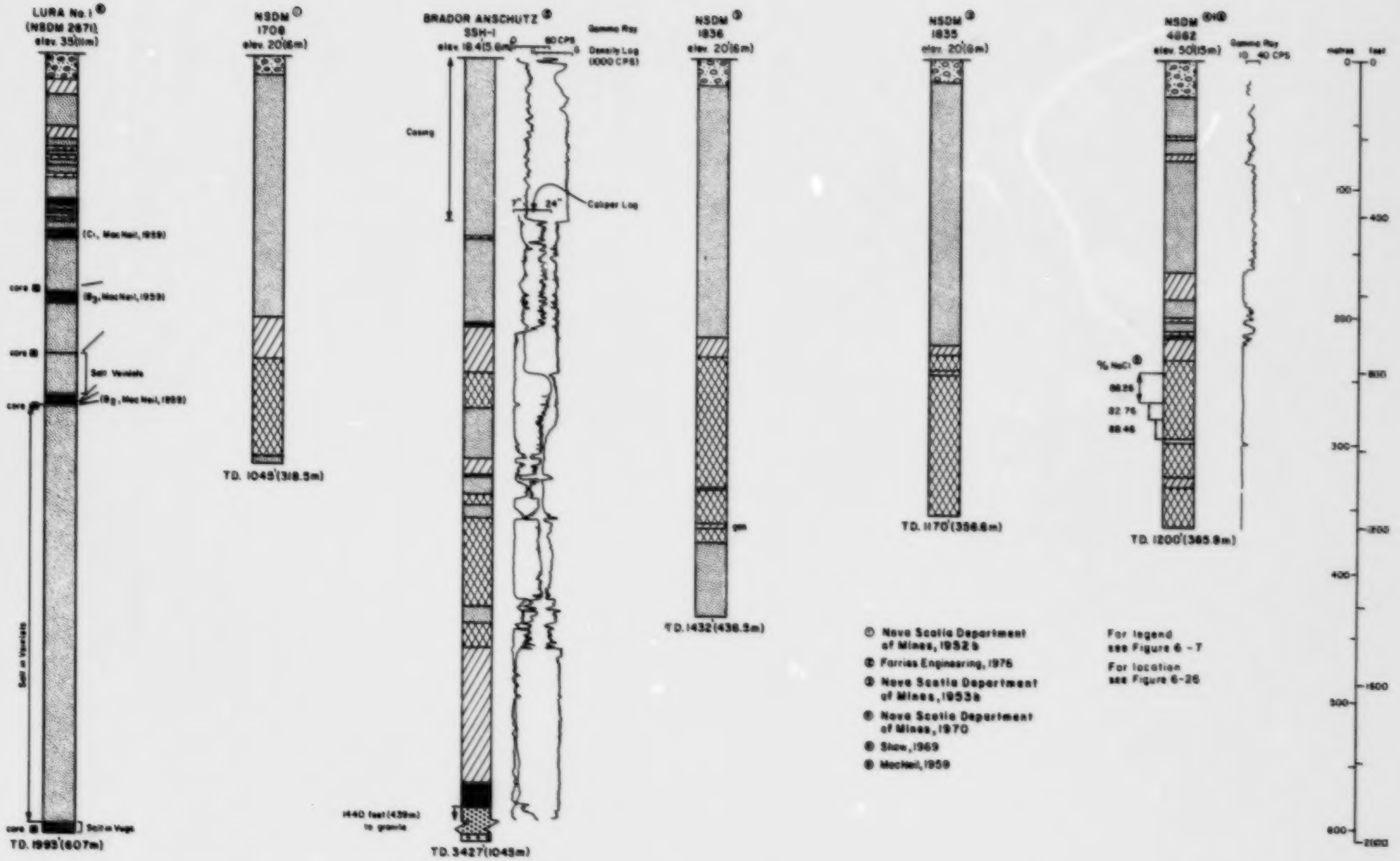

LURA No.1 ⑤
(NSDM 2671)
elev. 35'(11m)
(C₁, MacNeil,1959)
core ⑥
(B₃, MacNeil,1959)
core ⑥
Salt Veinlets
core ⑥
(B₂, MacNeil,1959)
Salt in Veinlets
core ⑥
Salt in Vugs
T.D. 1993'(607m)
NSDM ①
1706
elev. 20'(6m)
T.D. 1045'(318.5m)
BRADOR ANSCHUTZ ②
SSH-1
elev. 18.4'(5.6m)
0
80 CPS
5
Gamma Ray
Density Log
(1000 CPS)
Casing
7"
24"
Caliper Log
1440 feet (439m)
to granite
T.D. 3427'(1045m)
NSDM ③
1836
elev. 20'(6m)
gm
T.D. 1432'(436.5m)
NSDM ③
1835
elev. 20'(6m)
T.D. 1170'(356.6m)
NSDM ④⑤
4882
elev. 50'(15m)
Gamma Ray
10 40 CPS
% NaCl ⑤
88.25
82.76
88.46
T.D. 1200'(365.8m)
metres
feet
0
0
100
400
200
800
300
1200
400
1600
500
600
2000
① Nova Scotia Department of Mines, 1952b
② Farries Engineering, 1976
③ Nova Scotia Department of Mines, 1953b
④ Nova Scotia Department of Mines, 1970
⑤ Shaw, 1969
⑥ MacNeil, 1959
For legend see Figure 6-7
For location see Figure 6-26

Figure 6-27. Drillhole profiles, Southside Harbour deposit, Antigonish County.

(1954) and has since been revised by Boehner (1980b) and summarized in Figure 6-5.

On the southern and southeastern sides of Antigonish Harbour several prominent hills between Williams Point and Captains Pond are evident. At Williams Point the Windsor Group onlaps onto these rocks and apparently oversteps the Devono-Carboniferous which is known only from deep subsurface data. Murray (1971) described a fossiliferous mound-like limestone encircling the granodiorite knobs and ridges in this area and indicated a basal granite (granodiorite) pebble limestone conglomerate at the top of the granite. This limestone was described as the B_1 limestone by Sage (1954) based on its megafaunal assemblage, however Boehner and Giles (1982) correlated it with the Gays River Formation. A similar development of a mound-like limestone on granite occurs in the Calpo Limestone Company quarry near Southside Antigonish Harbour. Both are surrounded and overlain by gypsum and anhydrite of the Bridgeville Formation. Drilling indicates the Gays River Formation limestone continues down the erosional contact slope with the granite (Fig. 6-7).

The Brador Anschutz South Side Harbour No. 1 well (Farries Engineering, 1976) (Fig. 6-27) located 1.5 km east of the Calpo Limestone quarry, intersected Devono-Carboniferous clastic rocks with a thickness of approximately 440 m. In this well the basal Windsor Group limestone (Macumber Formation) is overlain by approximately 100 m of massive anhydrite (Bridgeville Formation) and then 200 m of halite with interbedded anhydrite and shale (Hartshorn Formation). This section is separated from 250 m of red shale with minor grey shale of the Hastings Formation by the Antigonish Thrust Fault. A cross-section through this hole and the other drilling in the area (Fig. 6-28) is interpreted differently than Sage (1954) and Shaw (1969). This revised interpretation is based on the new deep drillhole data and partly on experience in the Shubenacadie area in central Nova Scotia where fossiliferous A Subzone mound-like or bank carbonate deposits (Gays River Formation) occur in areas where the Windsor Group oversteps the Horton Group (Giles et al., 1979).

In addition to the Antigonish Thrust Fault there are several major faults in the Southside Harbour deposit area. The Monks Head Fault (Fig. 6-26) is a northeasterly trending high angle fault that parallels the Lanark and Morristown Faults (Fig. 6-6). The Antigonish Thrust Fault is the most important with respect to salt and potash exploration. Deformation in the area ranges from broad open folds near Southside Antigonish Harbour to steeply dipping overturned folds near Monks Head.

The Southside Harbour salt deposit was initially outlined by 3 diamond-drill holes, NSDM 1708, 1835 and 1836, drilled by the Nova Scotia Department of Mines (1952b, 1953b) in the early 1950's. In these holes the gently dipping halite is interbedded with red shale and anhydrite (Fig. 6-27). In 1969 Novasel Ltd. drilled Novasel No. 1 in an attempt to extend the salt mass further to the east (Shaw, 1969). Although the halite section was not completely penetrated, a substantial section of halite with some anhydrite and shale interbeds was intersected.

In 1976 Brador Oil Company Limited drilled Brador Anschutz Southside Harbour No. 1 near NSDM 1708 and NSDM 1836 (Farries Engineering, 1976). This hole was the first to be drilled through the Devono-Carboniferous to pre-Carboniferous basement (Fig. 6-28). The entire Windsor Group section present was intersected and the total thickness and stratigraphic position of the halite above the Bridgeville Formation sulphate and basal Windsor carbonate was established. Limestone beds were reported as thin interbeds with the halite, red shale and anhydrite which may indicate that the section above the upper part of the salt may be part of the Addington Formation. Drill core from this part of the section is not available, consequently the details of the stratigraphic assignment of the units are not clear.

Exploration in the area has not been restricted to the Southside Harbour area. In 1958 Lura Corporation Limited drilled Lura No. 1 approximately 2.5 km northeast of the soda ash project drilling (MacNeil, 1959). The hole was not entirely cored, but salt was reported to occur sporadically as thin beds, veins and cement (Fig. 6-27). The hole was prematurely abandoned at 607 m (1993 ft.) due to drilling difficulties without penetrating the main salt section. MacNeil (1959) correlated the carbonate units with the B_2, B_3, and C_1 limestones of Sage (1954). If the structural complexity evident in the Monks Head section, located 1.5 km north and described by Schenk (1969), extends into the area of Lura No. 1, then any assignment in the absence of a complete cored section becomes tenuous.

In 1973 and 1974 Imperial Oil Limited undertook a base metal exploration diamond-drill program in the area of Pomquet southeast of the Southside Harbour deposit and near Captains Pond to the northeast. Seven holes (PQ series) were drilled in the vicinity of Sage's (1954) Saw Mill section (Upper Windsor) near Pomquet (Fig. 6-26). Salt residue was reported in some of the core. This drilling confirms and locates more precisely the Monks Head Fault originally mapped by Sage (1954) and the previously unrecognized Pomquet Station Fault.

Eight holes (CP series) were drilled by Imperial Oil near Captains Pond. Seven were drilled near an E_1 limestone outcrop located approximately midway between Captains Pond and Monk Pond. These drillholes are located near the Monks Head limestone deposit described by Murray (1975). The drilling by Imperial Oil encountered a disturbed and locally overturned section of Upper Windsor rocks. A single hole CP74-5 was drilled farther to the west of Captains Pond on the eastern side of a granite knob. This hole penetrated granite at a depth of 52 m (170 ft.) beneath overburden.

GEOPHYSICS

A gravity survey by the Seismograph Service Corporation (Pohly, 1952a) outlined three residual gravity maxima on the same trend as the Monks Head Fault (Fig. 6-29). Another elongate

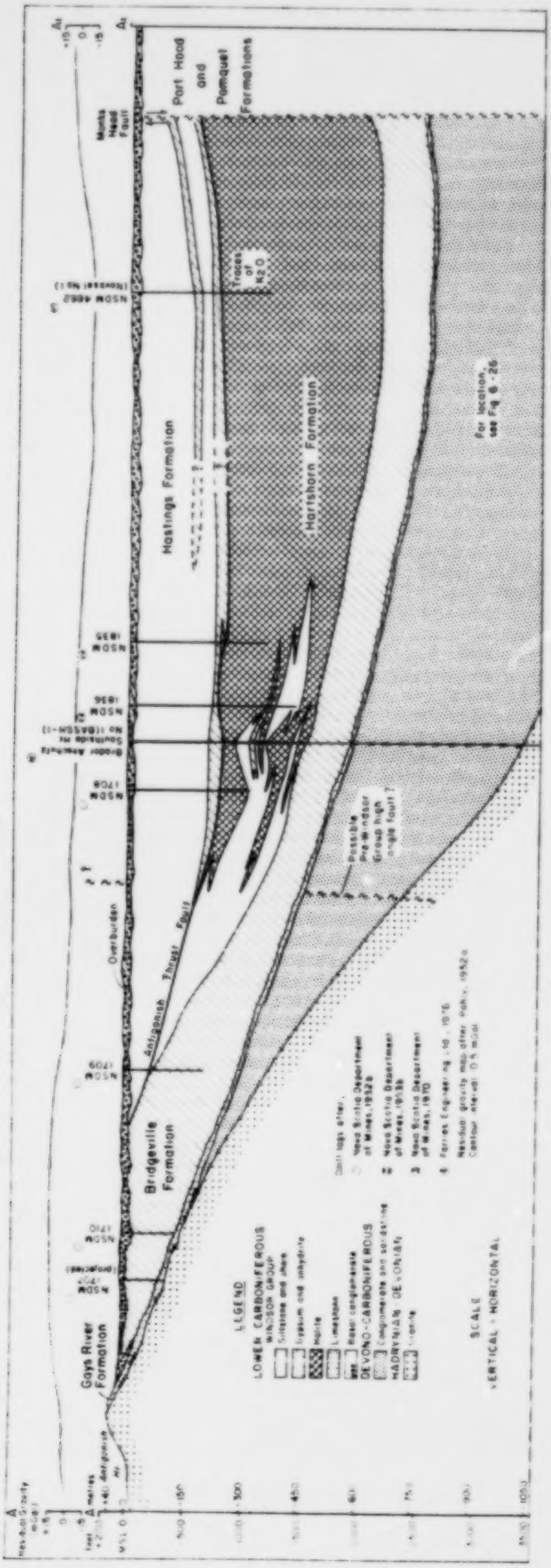

A
A₁
Gays River Formation
Bridgeville Formation
Overburden
Antigonish Thrust Fault
Hastings Formation
Hartshorn Formation
Traces of K2O
Port Hood and Pomquet Formations
Monks Head Fault
Possible Pre-Windsor Group high angle fault?
For location, see Fig 6-26
NSDM 1707 (projected)
NSDM 1710
NSDM 1709
NSDM 1708
Southside Hr No 1 (BASSH-1)
NSDM 1836
NSDM 1835
NSDM 4882 (Novacal No 1)
metres
feet
MSL 0
150
300
450
600
750
900
1050
LEGEND
LOWER CARBONIFEROUS
WINDSOR GROUP
Siltstone and shale
Gypsum and anhydrite
Halite
Limestone
Basal conglomerate
DEVONO-CARBONIFEROUS
Conglomerate and sandstone
HADRYNIAN - DEVONIAN
Granite
Drill logs after:
Nova Scotia Department of Mines, 1952a
Nova Scotia Department of Mines, 1953b
Nova Scotia Department of Mines, 1970
Forres Engineering Ltd., 1976
Residual gravity map after Pohl, 1952a
Contour interval: 0.5 mgal
SCALE
VERTICAL = HORIZONTAL

Figure 6-28. Geological and gravity cross-section, Southside Harbour deposit, Antigonish County.

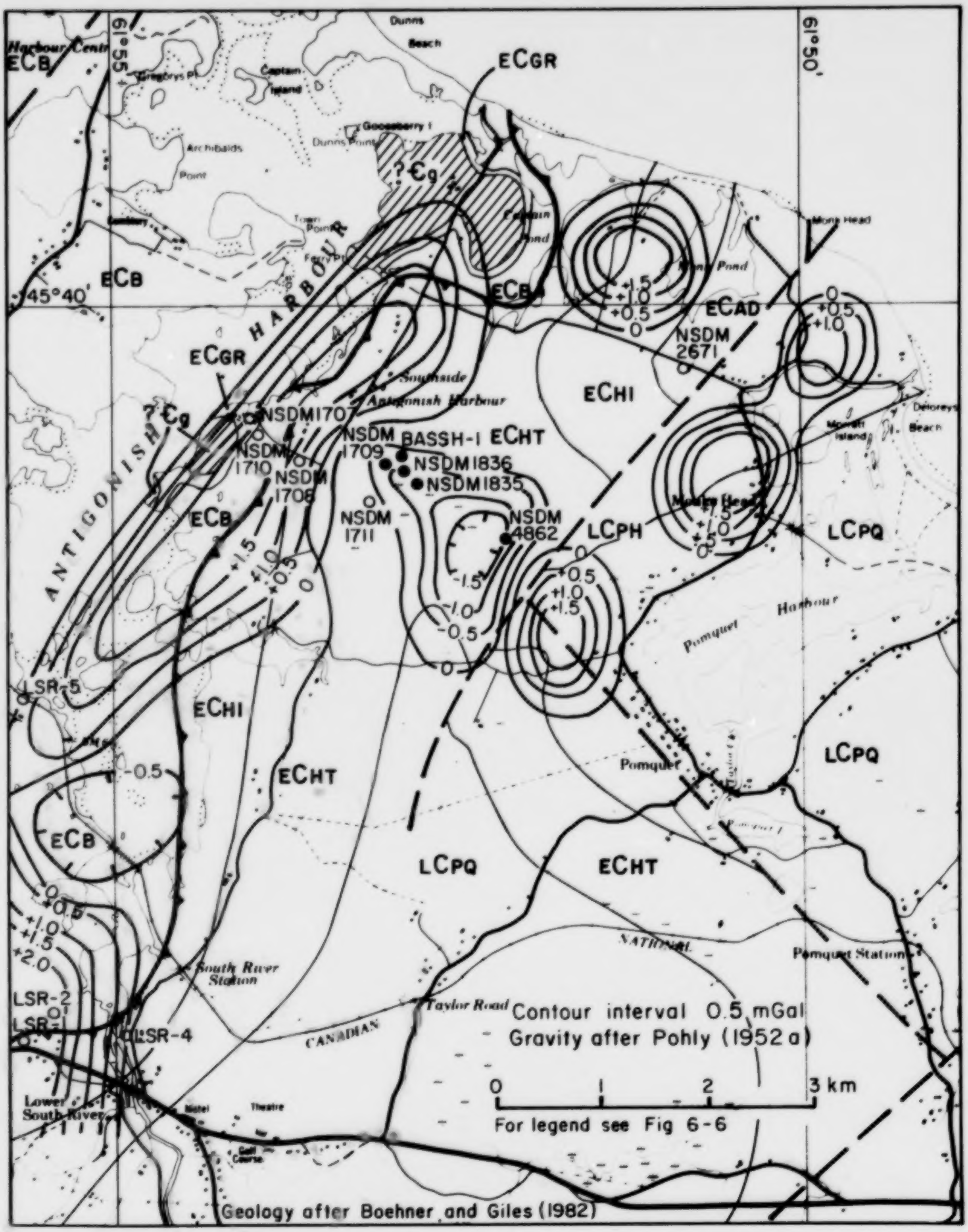

Dunns Beach
ECGR
61°55'
61°50'
Harbour Centre
ECB
Gregorys Pt
Captain Island
Gooseberry I
Dunns Point
Archibalds Point
?Cg
Captain Pond
Town Point
Ferry Pt
HARBOUR
ANTIGONISH
Mahoneys Pond
Monk Head
45°40'
ECB
ECAD
NSDM 2671
ECGR
Southside
Antigonish Harbour
ECHI
?Cg
NSDM1707
NSDM 1709
BASSH-1
ECHT
NSDM 1710
NSDM1836
NSDM1835
NSDM 1708
NSDM 1711
NSDM 4862
LCPH
LCPQ
Deloreys Beach
Morgan Island
Mahoney Head
+1.5
+1.0
+0.5
0
-0.5
-1.0
-1.5
LSR-5
ECHI
ECHT
Pomquet Harbour
Pomquet
LCPQ
ECB
LCPQ
ECHT
NATIONAL
Pomquet Station
+2.0
South River Station
LSR-2
LSR-1
LSR-4
Taylor Road
CANADIAN
Contour interval 0.5 mGal
Gravity after Pohly (1952 a)
0
1
2
3 km
For legend see Fig 6-6
Lower South River
Motel
Theatre
Golf Course
Geology after Boehner and Giles (1982)

Figure 6-29. Residual gravity anomaly map, Southside Harbour deposit, Antigonish County.

positive anomaly coincides with the relatively dense granite and anhydrite in the Williams Point-Captains Pond trend. Exploration drilling has confirmed that a negative residual gravity anomaly coincides with the salt deposit and occurs between the previously described positive anomalies. In order to more fully evaluate the extension of the salt mass to the northeast and southwest, detailed gravity survey and exploratory drilling are required.

In 1958 the Nova Scotia Research Foundation (1959c) was employed by Lura Corporation for gravity magnetic and reflection seismic surveys and interpretations in the Southside Harbour-Monks Head area. Two gravity profiles were constructed with trends of west-northwest to east-southeast. In one of the gravity-geology sections drawn with some drillhole control, the Monks Head Anticline is indicated to be fault bound on the east and west which agrees with the inferred fault in Figure 6-28.

Two reflection seismic profiles were surveyed by the Nova Scotia Research Foundation (1959c). One line (Line 7) (Fig. 6-26) is oriented approximately northwest-southeast and is situated immediately southwest of the line of the Southside Harbour cross-section (Fig. 6-30). This profile suggests that the strata are nearly horizontal above the salt. The second line (Line 8), trending approximately east-west, is located along the northern road between Southside Antigonish Harbour and Monks Head approximately 1.5 km north of the Southside Harbour cross-section (Fig. 6-30). This profile is more difficult to interpret, but the section is probably folded and somewhat broken in the area.

GEOCHEMISTRY

Two drillhole salt sections from the Southside Harbour deposit have been analyzed for major constituents. Analyses from NSDM 1708 are reported by the Nova Scotia Department of Trade and Industry (Nova Scotia Department of Mines, 1952a) (Table 6-7). The interval 244-282 m (800-925 ft.) has an average analyses of 85.77% NaCl and the interval 297-308 m (975-1009.5 ft.) has an average grade of 81.9% NaCl. Analyses of salt samples from Novasel No. 1 (NSDM 4862) are presented in Table 6-8. In Novasel No. 1 the intervals 242-267 m (795-875 ft.) have an average grade of 88.19%; 267-280 m (875-920 ft.), 82.67%; and 280-296 m (920-970 ft.), 88.5%. Baar (1966) studied the bromine geochemistry of salt in Nova Scotia with particular reference to its potential use as a potash prospecting method. In the Antigonish area the NSDM 1708 drillhole was selected for Br and NaCl analyses. The results of these analyses are presented in Figure 6-31. He concluded that the normal bromine contents

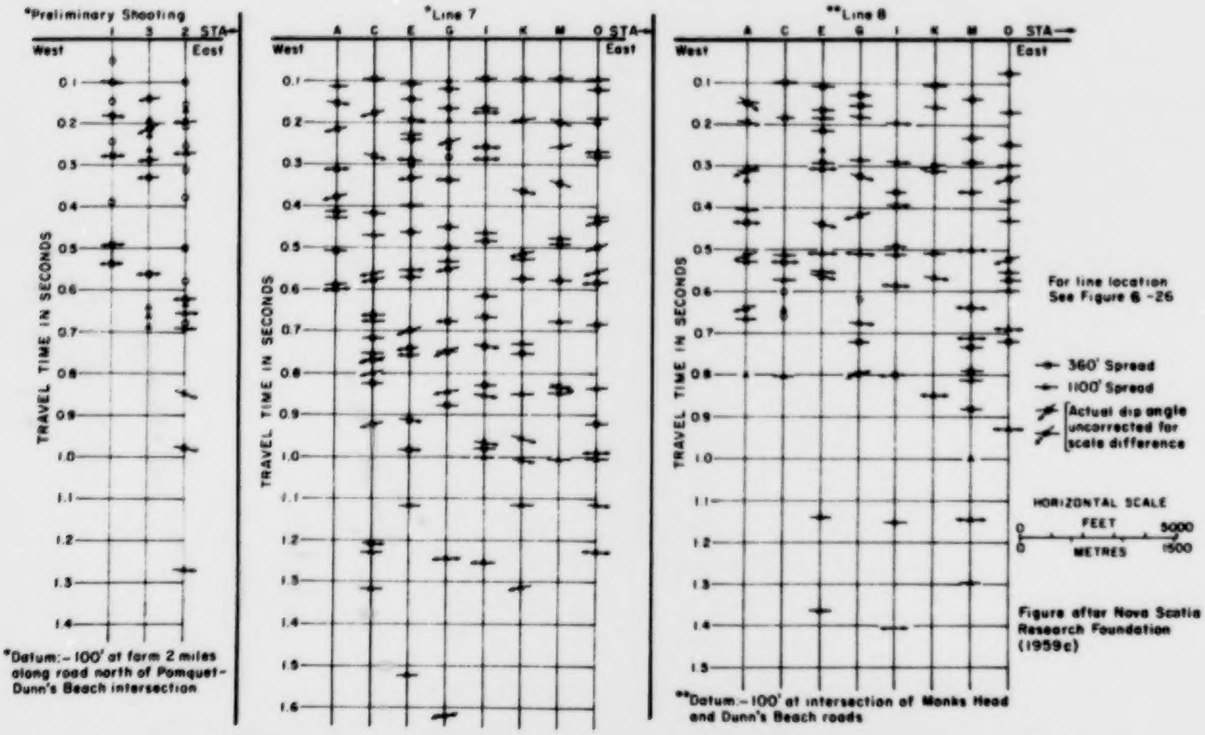


Figure 6-30. Reflection seismic survey, Lines 7 and 8, Southside Harbour deposit, Antigonish County.

indicating low degrees of concentration persisted through the section. Some irregular bromine contents in secondary halite indicated the migration of higher concentrated solutions through parts of the section. He attributed the higher, 0.27% K (as opposed to the normal, less than 0.07%), to this phenomenon. Traces of potash salts were noted in Novasel No. 1 at approximately the same depth as the 0.27% K analysis (Boehner, unpublished drill log, 1979).

ECONOMIC CONSIDERATIONS

The Southside Harbour deposit contains halite and some minor traces of potash. Two of the salt sections have been analyzed and the following intervals and NaCl grades are reported. In NSDM 1708, the interval 291-313 m (800-925 ft.) has an average analyses of 85.77% NaCl and the interval 291-313 m (959.5-1026.5 ft.) has an average analyses of 80.7%. In Novasel No. 1 the complete interval, 242-296 m (795-970 ft.) has an average grade of 86.5%. The top of the salt in the Southside Harbour deposit occurs at depths of between 242 and 296 m (760 and 800 ft.). The salt section thickness is in the order of 213 m (700 ft.). The salt occurs over a width of greater than 1000 m, but its continuation has not been confirmed by exploration drilling. Further exploration drilling and gravity surveys will be required to determine the quantity, quality and economic viability of the deposit.

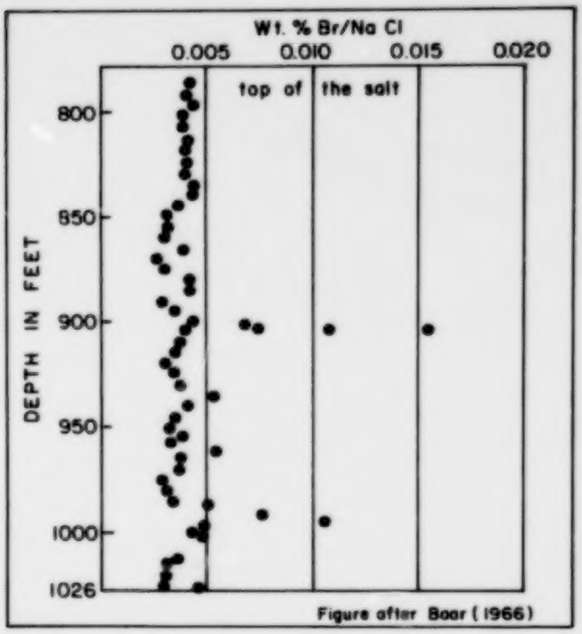


Figure after Baar (1966)

Figure 6-31. Bromine profile, NSDM 1708, Southside Harbour deposit.

Table 6-7. Chemical analyses, NSDM 1708, Southside Harbour, Antigonish County; analyses reported in per cent.*

Interval (feet)	NaCl (from Cl)	$CaSO_4$ (S)	Water Insol.	Moist.	Loss at 275°C	Tot.	R_2O_3	SO_3	CaO	MgO	Cl
785 - 800	78.80	4.17	16.86	0.11	nil	99.94	nil	2.45	1.79	nil	47.80
800 - 825	85.62	3.96	11.84	0.08	nil	101.5	nil	2.30	1.73	nil	51.94
825 - 838	85.14	4.17	10.09	0.17	nil	99.57	trace	2.45	1.57	nil	51.64
838 - 850	87.44	3.58	6.43	0.05	nil	97.50	nil	2.11	1.65	nil	53.04
850 - 871.5	88.05	3.99	6.85	0.04	nil	98.93	nil	2.35	1.76	nil	53.41
871.5- 900	85.54	5.15	8.41	0.09	nil	99.19	nil	2.83	2.21	nil	51.89
900 - 903	88.43	5.43	6.04	0.15	nil	100.05	trace	3.19	2.32	nil	53.64
903 - 909	83.93	3.43	12.73	0.09	nil	100.01	nil	2.02	1.50	nil	50.91
909 - 925	82.81	3.33	13.75	0.12	nil	100.01	trace	1.95	1.46	nil	50.23
925 - 928.5	17.75	3.33	79.36	0.11	nil	100.55	nil	1.96	1.64	nil	10.77
928.5- 949	75.89	3.40	20.93	0.06	nil	100.3	nil	1.99	1.51	nil	46.04
949 - 952.5	70.59	4.85	23.61	0.07	nil	99.1	nil	2.85	2.10	nil	42.83
952.5- 955.5	14.65	3.21	81.99	0.09	nil	99.9	nil	1.88	1.42	nil	8.89
955.5- 975	72.24	5.95	20.95	0.04	0.01	99.2	nil	3.50	2.50	nil	43.82
975 - 987.5	80.35	5.10	14.14	0.09	0.01	99.7	nil	3.00	2.20	nil	48.74
987.5-1005	79.02	2.08	19.27	1.13	0.06	100.6	nil	1.23	1.12	nil	47.93
1005 -1009.5	97.55	2.86	0.20	0.09	0.01	99.6	nil	1.03	0.80	nil	57.83
1009.5-1021	60.95	2.15	33.90	2.40	0.16	99.6	nil	1.56	1.40	nil	36.97
1021 -1026.5	94.78	2.86	1.98	0.12	0.02	99.8	nil	1.68	1.26	nil	57.49
1026.5-1035	30.87	3.10	62.10	3.87	0.62	100.6	nil	1.82	2.10	trace	18.73
1035 -1049	49.25	2.36	43.23	2.44	0.40	98.0	nil	1.30	1.65	trace	29.87

*Analyst Dr. W. T. Foley, St. Francis Xavier University, Antigonish, Nova Scotia (Nova Scotia Department of Mines, 1952a)

Table 6-8. Chemical analyses, Novasel-1 (NSDM 4862), Southside Harbour, Antigonish County; analyses reported in per cent.**

Interval (feet)	NaCl Na(2.54)	NaCl Cl(1.65)	Ca	SO$_4$	Insoluble Residue	Loss on Ignition	K	Mg	Sr
787 - 790	88.27	89.43			3.28				
790 - 795	84.33	85.17			6.32				
795 - 800	89.41	88.19			3.00				
800 - 805	88.39	89.02	1.08	1.58	3.66	-0.05*	0.01	-0.0004*	-0.05*
805 - 810	88.90	87.91			4.25				
810 - 815	86.87	88.19			4.28				
815 - 820	86.79	89.84			3.41				
320 - 825	86.87	88.74			3.80				
325 - 830	88.39	88.46			3.32				
830 - 835	89.66	90.23			2.28				
835 - 840	87.63	87.63			4.62				
840 - 845	87.63	88.46			3.75				
845 - 850	88.39	89.00			3.73				
850 - 855	87.89	87.85			6.30				
855 - 860	89.50	88.26			6.13				
860 - 865	91.06	92.02	0.88	1.70	3.34	0.10	0.02	-0.0007	-0.0004
865 - 870	89.17	91.46			3.14				
870 - 875	85.59	87.25			5.76				
875 - 880	83.44	84.78			8.18				
880 - 885	83.19	86.03			6.56				
885 - 890	84.71	86.31			6.28				
890 - 895	83.69	84.78			7.65				
895 - 900	79.12	80.31	1.43	2.76	10.89	0.06	0.06	-0.0007	-0.0004
900 - 905	81.15	63.52			9.40				
905 - 910	84.96	84.50			8.24				
910 - 915	81.40	85.06			8.21				
915 - 920	83.19	85.34			7.45				
920 - 925	86.46	89.23			4.89				
925 - 930	90.50	89.51			6.18				
930 - 935	92.33	90.07			4.64				
935 - 940	86.36	89.79	1.01	1.85	4.42	0.10	0.27	-0.0007	-0.0004
940 - 945	87.63	89.23			5.16				
945 - 950	88.90	89.51			4.32				
950 - 955	88.27	89.79			4.85				
955 - 960	88.39	86.44			7.06				
960 - 965	87.38	87.00			11.09				
965 - 970	88.39	89.23			4.18				
970 - 975	75.06	78.08	1.00	1.99	15.96	0.91	0.09	0.007	-0.0004*
975 - 985	72.52	70.83			18.46				
985 - 995	80.77	79.18			13.90				
995 -1005	79.25	80.59			13.61				
1005 -1015	75.69	77.93	1.46	2.58	16.13	0.15	0.02	-0.0007*	-0.0004
1015 -1025	80.27	76.38			14.67				
1025 -1035	50.82	57.82			38.83				
1035 -1045	71.12	73.71			18.69				
1045 -1050	42.80	43.87	0.72	3.65	46.72	0.16	0.02	-0.0007	-0.0004
1050 -1060	77.85	78.21			15.37				
1060 -1070	40.39	40.51			49.11				
1095 -1105	61.09	59.68	0.64	3.61	29.98	0.09	0.02	-0.0007	-0.0004
1105 -1115	80.13	82.27			10.09				
1115 -1125	83.57	84.12	1.60	2.32	9.14	0.13	0.02	-0.0007	-0.0004
1125 -1135	77.22	77.65			14.35				
1135 -1145	76.19	78.49			15.15				
1145 -1155	82.29	82.71			10.62				
1155 -1165	78.23	80.47			12.45				
1165 -1175	77.98	77.37			13.63				
1175 -1185	82.30	83.84			12.90				
1185 -1195	77.98	80.47	1.37	2.37	11.94	0.11	0.03	-0.0007	-0.0004
1195 -1200	75.95	77.09			14.73				

**Analyst K. S. MacLean, Nova Scotia Research Foundation, Dartmouth, Nova Scotia (Shaw, 1969).
*less than

CHAPTER 7
CANSO-BRAS D'OR AREA

INTRODUCTION

The Canso-Bras d'Or area encompasses the Carboniferous outcrop areas in southeastern and central Cape Breton Island and is located in portions of Inverness, Richmond, Cape Breton and Victoria Counties (Fig. 1-10). Hayes (1931) outlined the salt-potash exploration potential of the area as part of a Province-wide potash survey. Many salt springs and seeps were located and analyzed. With the exception of some unsuccessful drilling at Bucklaw in the early 1920's, no significant attempts to exploit salt were made until the mid 1960's when Dow Chemical Limited and Domtar Limited began exploration near the Strait of Canso. Several major salt deposits were outlined with planned uses including salt mining and developing underground storage facilities. These deposits have been relatively well-defined by diamond-drill holes and gravity surveys.

The geology in the Canso-Bras d'Or area has been described in the reports and maps by Ferguson (1946), Ferguson and Weeks (1950), Weeks (1954), Collins (1962), Kelley (1967b), Bell (1958), Milligan (1970), Shea and Wallace (1962), and Jones and Covert (1972).

The nine deposits which have been outlined in the Canso-Bras d'Or area are: the Cleveland, Estmere, Kingsville , McIntyre Lake, Malagawatch, Orangedale, Port Richmond, St. Patricks Channel, and St. Peters (Fig. 7-1). Data on the Cleveland, Estmere and St. Patricks Channel deposits have become available after the completion of this report. Consequently they have not been described in the format of the other deposits. For similar reasons the Malagawatch and Orangedale deposits are not completely described.

The Kingsville deposit outlined by Domtar Limited is defined in twelve diamond-drill holes. A brining test well has indicated that salt could be produced using that method. The McIntyre Lake deposit contains four diamond-drill holes and it has been under investigation by Home Oil Canada Limited et al. for potential underground storage development. The Malagawatch deposit has been outlined in potash exploration drillholes by Chevron Standard Ltd. The Orangedale deposit is defined from one hole drilled by Noranda Exploration Ltd. The Port Richmond deposit is outlined by 5 diamond-drill holes and has been evaluated by Dow Chemical Limited for underground storage purposes. The St. Peters deposit is the least well-defined deposit because it contains only one drillhole. The Seaview occurrence is the only salt occurrence known in the area and it is defined in only a single drillhole by Domtar Limited.

GENERAL GEOLOGY AND CARBONIFEROUS STRATIGRAPHY

The Canso Bras d'Or area includes the Bras d'Or Sub-basin of Bell (1958) and the area to the south of the Sydney Sub-basin. The geology in this area is poorly understood and probably rather complex. The Carboniferous rocks, including the Windsor Group, occur in a series of interconnected outcrop areas separated by highland areas of pre-Carboniferous rocks.

The pre-Carboniferous basement rocks comprise complex intrusive and metamorphic massifs of Lower Paleozoic to Proterozoic age. These basement blocks are unconformably overlain by and surrounded in whole or in part by the Lower Carboniferous Horton Group terrigenous rocks, comprising interstratified sandstone, shale and conglomerate. The stratigraphy of the Horton Group has been studied in some detail by several workers including Murray (1960) and Kelley (1967b) who described the basic stratigraphic subdivisions in Cape Breton. These subdivisions were outlined in the introductory section of the Antigonish-Mabou area. Kelley (1967b) presented an isopach map showing original thicknesses of the Horton Group in central and western Cape Breton. The major areas of deposition and the approximate area of pinchout and Windsor Group onlap are readily seen on this map. Major deposition occurred to the west of the Creignish Hills and also in the Whycocomagh-Lake Ainslie area (Fig. 7-1).

Although not contoured by Kelley (1967b) the Strait of Canso-St. Peters area may also be inferred to have substantial sections of Horton Group rocks (Weeks 1954; Ferguson and Weeks 1950; and Ferguson, 1946). In its thickest sections, such as in Graham River, Kelley (1967b) measured in excess of 3000 m. These sections may thin drastically by pinchout and onlap to less than a few hundred metres or to nil in the vicinity of pre-Carboniferous basement highs. In areas of such extreme thinning and Windsor Group onlap it has been a mapping difficulty to determine which terrigenous rocks are Horton Group and which are Windsor. An example of this situation occurs along the southeastern contact of the River Denys Basin. This border of the Basin is defined by the pre-Carboniferous basement rocks of North Mountain (Fig. 7-1). Along the border, Kelley (1967b) mapped a band of red sandstone and conglomerate, and assigned the unit to a marginal facies of the Horton and/or Windsor Groups in a fashion after Weeks (1954). Weeks (1954) indicated the Windsor Group in the southeastern part of Cape Breton occurred in two distinct relationships with underlying rocks, the "Central Basin Succession" and "Marginal Basin Succession". The marginal basin succession occurs in onlap relationship with pre-Carboniferous rocks. It is invariably associated with coarse, ill-sorted conglomerate and interpreted as marginal facies of the more basinal sections which rest on Horton Group rock.

Bell and Goranson (1938) introduced the term Grantmire member and applied it to coarse terrigenous rocks beneath lower Windsor marine strata in the Sydney map area, which were believed to have been marginal basal Windsor Group facies. Weeks (1954) applied the name Grantmire Formation to a conglomerate and sandstone unit in the St. Peters map area and considered it part of the Windsor Group. This unit was also mapped in the Iona-Washabuck area. More recently Kelley (1967b), in the adjoining

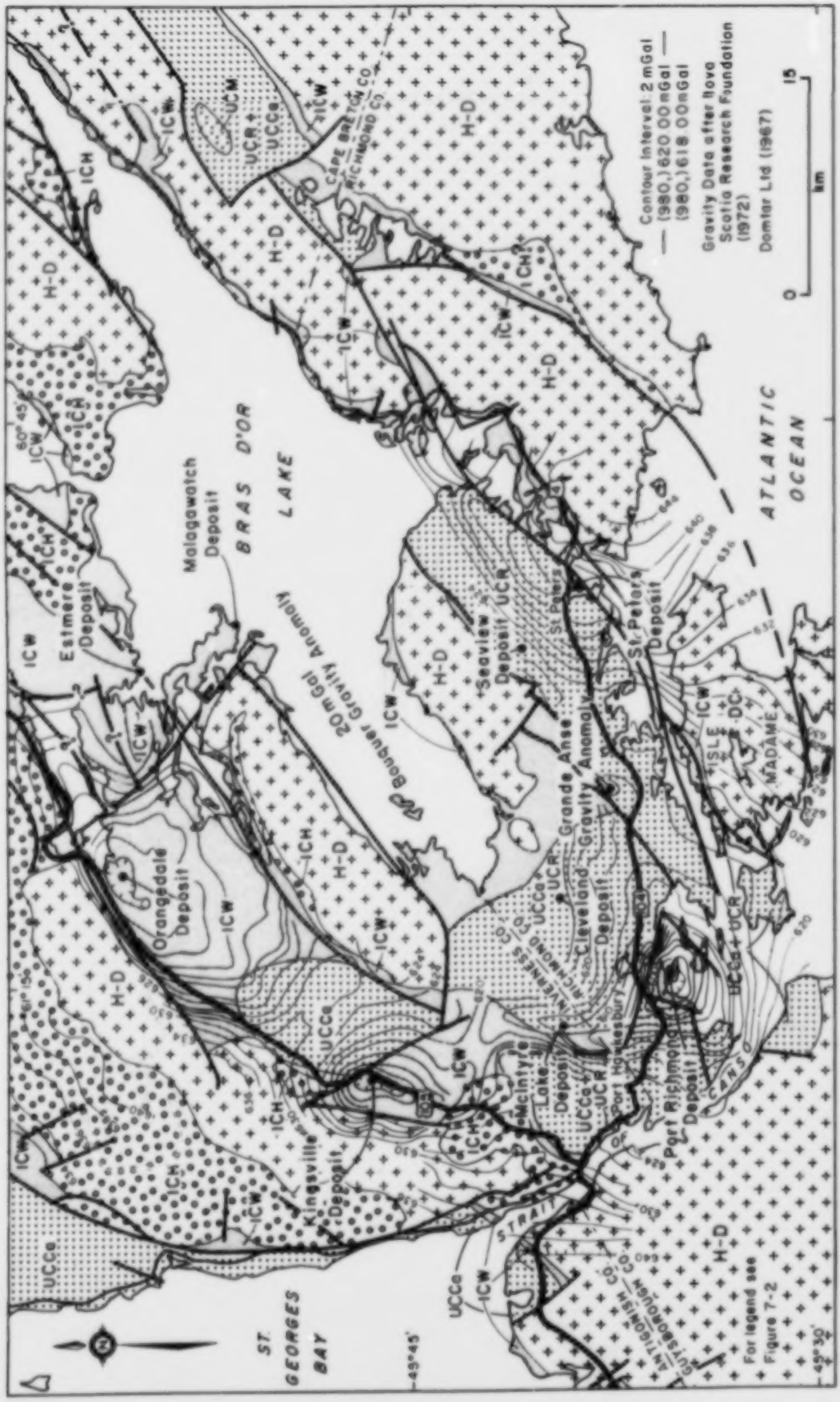

ST. GEORGES BAY
BRAS D'OR LAKE
ATLANTIC OCEAN
STRAIT OF CANSO
ISLE MADAME
Orangedale Deposit
Malagawatch Deposit
Estmere Deposit
Kingsville Deposit
McIntyre Lake Deposit
Port Hawkesbury
Port Richmond Deposit
Cleveland Deposit
Grande Anse Gravity Anomaly
Seaview Deposit
St. Peters
St. Peters Deposit
20 mGal Bouguer Gravity Anomaly
INVERNESS CO.
RICHMOND CO.
CAPE BRETON CO.
RICHMOND CO.
ANTIGONISH CO.
GUYSBOROUGH CO.
H-D
ICW
ICH
ICH?
UCCa
UCR
UCM
UCR + UCCa
DC
60°45'
61°15'
45°45'
45°30'
For legend see Figure 7-2
Contour Interval: 2 mGal
(980,)620.00 mGal
(980,)618.00 mGal
Gravity Data after Nova Scotia Research Foundation (1972)
Domtar Ltd (1967)
0
15
km

Figure 7-1. Composite Bouguer gravity anomaly map, Canso-Bras d'Or area, Cape Breton Island.

map area recognized typical Horton Group rocks rather than Grantmire introducing a nomenclature conflict. In this specific area, modification and reassignment of the coarse terrigenous map unit to the Horton Group is not a problem, because a typical basal Windsor carbonate and lower sulphate succession are apparent at the topographic and mapped boundary. In other areas, the problem is not so easily resolved however, especially where conglomerate is interstratified with the marine carbonates of the Windsor Group Loch Lomond area (Boehner, 1981b).

With the exception of the River Denys and Strait of Canso-St. Peters areas, the Windsor Group outcrops in small areas peripheral to the Highlands. The Bras d'Or Lakes occupy a large part of the Carboniferous Lowland area in central Cape Breton. The stratigraphy of the Windsor Group in the central and southeastern Cape Breton Island areas has not been studied or described in any detail. Ferguson (1946), Weeks (1954) and Kelley (1967b) did however, make important observations regarding contact relationships. These, when considered with more recent subsurface data and extrapolation from other areas, make it possible to interpret the stratigraphy of a given area even though the picture as a whole may not be clear.

The Windsor Group stratigraphy in the Antigonish-Mabou area, as interpreted by Norman (1935), Sage (1954) and Stacey (1953), was outlined in the previous section. Norman (1935) measured 530 m (1739 ft.) of Windsor Group in the Port Hood Island section. Here the basal Windsor limestone and lower part of the section including the main salt and anhydrite section are apparently absent. Stacey (1953) measured 542.5 m (1780 ft.) in the same section and estimated a total thickness for the Windsor Group in western Cape Breton Island of 670-823 m (2200 to 2700 ft.). Stacey (1953) also measured and described the Cape Dauphin section near the northeastern tip of Kellys Mountain and reported 306 m (1005 ft.) of Windsor Group. In this section he concluded that much of the Lower Windsor was absent due to faulting. Sage (1954), in contrast, considered the base to be an unbroken B Subzone succession. Whether this section represents marginal onlap or faulting is uncertain.

Experience mapping Windsor Group rocks on mainland Nova Scotia indicates the most important interval with regard to thick salt occurs above the lower sulphate-basal Windsor limestone section and beneath the interstratified siltstone, sandstone, gypsum-anhydrite, and limestone dolostone that comprise the middle and upper parts of the Windsor Group. Thinner and possibly significant salt horizons, however may also occur at any level in the Windsor Group. In central Nova Scotia they are known to occur above the highest Windsor Group carbonate member (Giles and Boehner, 1979; Giles, 1980).

In central and southern Cape Breton the basal limestone-evaporite section is well represented. It was referred to as "basal laminated limestone" by Weeks (1954) and Ferguson (1946) and "A_1 Windsor limestone" by Kelley (1967b). This unit concordantly and probably conformably overlies the Horton Group (Kelley 1967b; and Ferguson, 1946). The unit was originally described by Ferguson (1946) as a fine grained, dull grey rock with individual laminae one-quarter inch thick and a maximum total thickness of approximately 20 m (65 ft.). Weeks (1954) reported that the lower most bed in his "central basin succession" is a characteristic black, laminated, sandy, unfossiliferous limestone with a maximum thickness of approximately 21 m (70 ft.). Kelley (1967b) described the A_1 limestone as thinly laminated, fine grained, medium to dark grey with quartz or gypsum and anhydrite grains scattered on bedding planes. Kelley (1967b) also reported Ostracoda and *Spirorbis* at several localities of the A_1.

A thick section of anhydrite normally overlies the basal Windsor limestone. Broad outcrop belts of anhydrite and gypsum are evident on maps and drilling has established thick anhydrite sections (locally exceeding 300 m) near Little Narrows at Jubilee and in the River Denys area. In some areas, the basal part of the Windsor Group section is complicated by onlap onto intrabasinal highs such as along the northwestern side of North Mountain where Kelley (1967b) and Ferguson (1946) reported basal limestone overlying thin conglomerate on pre-Carboniferous rocks. More extreme onlap and the appearance of coarse terrigenous facies are evident in the Mira Hills-East Bay Hills area. Here the middle and upper Windsor sections have overlapped the basal Windsor section and were deposited directly on deeply incised pre-Carboniferous basement. This line of onlap occurs in the vicinity of the Bras d'Or Lake-East Bay shoreline along the northwestern side of the East Bay Hills. Spectacular onlap onto steep terrain is present in the Loch Lomond-Lake Enon area (Boehner, 1981b; Forgeron, 1977; and Crowell, 1971).

The stratigraphy of the post-salt rocks comprising mainly the middle and upper parts of the Windsor Group is not well understood in the area. No stratigraphic columns or measured sections have been described by previous workers with the exception of the aforementioned Loch Lomond area. Examination of the maps and fossil localities described and reported by Kelley (1967b) indicate a substantial section might be worked out through field examination. It is reasonable to expect a succession with similar general stratigraphy to that described for western Cape Breton by Stacey (1953) and Norman (1935) or a section similar to that in the Shubenacadie Basin as described by Giles and Boehner (1979). Extreme variations in thickness may be present in the central and southern Cape Breton area due to rapid changes in topography. Postdepositional structural adjustments are also severe in most areas. Undisturbed areas with stratified salt sections are probably rare in the Canso-Bras d'Or area because of extensive tectonism.

The Windsor Group in the Canso-Bras d'Or area, as in other areas of Nova Scotia, is overlain conformably to disconformably by younger, typically nonmarine strata assigned to the Canso

Group and Riversdale or Pictou Groups. The section above the Windsor Group has a complex history of stratigraphic subdivisions and age assignment by a variety of workers including Ferguson (1946), Bell (1944), Belt (1962), Norman (1935), Kelley (1967b) and Weeks (1954). These rocks comprise stratified red and grey shale, sandstone, conglomerate and rare coal. Thickest and most complete Upper Carboniferous sections occur near the Strait of Canso, St. Peters and Kingsville. Bell (1944) indicated approximately 610 m (2000 ft.) of Canso Group in the type section at the Strait of Canso. Belt (1962) who incorporated the Canso and Riversdale Groups in this same section assigned more than 2743 m (9000 ft.) to his Mabou Group including 914 m (3000 ft.) considered by Ferguson (1946) to be Canso Group and more than 1829 m (6000 ft.) considered by Ferguson (1946) to be Riversdale Group. Kelley (1967b) calculated a minimum total thickness of 2134 m (7000 ft.) for the section of Upper Carboniferous, Mabou Formation (Canso-Riversdale Groups equivalent) in the Maple Brook Syncline near Kingsville. Kelley (1967b) reported that along the western border of the Maple Brook Syncline the Windsor Group A_1 limestone is overlain concordantly by 4.6 m (15 ft.) of red siltstone, which in turn is overlain by Mabou Formation. Further to the north the Mabou Formation overlies apparently younger Windsor Group strata.

Ferguson (1946) reported that the thickness of the Windsor Group beneath the Canso Group varied and attributed this to erosion of parts or, in some instances, nearly all of the original Windsor Group section. Kelley (1967b) suggested this erosion may have been contemporaneous with some Mabou Formation deposition. Areas where the Windsor Group is extremely thin occur mainly in the vicinity of the Strait of Canso, but also occur along the southeastern border of the Antigonish Basin. In the latter areas low-angle faulting is suspected along at least part of the contact between the Windsor and Canso Groups.

The complex stratigraphy in the Canso-Bras d'Or area is further complicated by faulting and folding. One major fault occurs on the northwestern side of the River Denys structural basin and brings the Windsor Group in contact with Horton Group and pre-Carboniferous rocks. The southeastern side of the area is likewise marked by major faults that extend from Lennox Passage northeasterly to the Salmon River area. Faulting in the area is dominated by a series of major northeast trending faults and fault systems that can be traced from the Strait of Canso-Chedabucto Bay area. Many major faults have been mapped by previous workers and more recent subsurface and geophysical data indicate others are probable. Interpretations of tectonics and sedimentation are included in the reports by Belt (1968), Kelley (1967b), Bell (1958), Ferguson (1946), and Weeks (1954). The reader is directed to these for more detailed descriptions.

KINGSVILLE DEPOSIT

The Kingsville deposit is located near Kingsville in the southwestern end of the River Denys Valley, Inverness County, Cape Breton (11F/14). Kingsville is located approximately 18 km north of the Port Hawkesbury-Point Tupper industrial area on the Strait of Canso (Figs. 1-10 and 7-1).

The area is easily accessible through a series of paved and unpaved roads connected with the Trans-Canada Highway 105 between Port Hastings and North Sydney. The Canadian National Railway mainline between Port Hawkesbury and Sydney is located on the eastern side of the River Denys Valley approximately 10 km east of Kingsville. The Port Hawkesbury regional airfield is situated off the Trans-Canada Highway 105, 15 km south of Kingsville.

The terrain in the vicinity of the Kingsville deposit (Fig. 7-2) is marked by distinct topographic contrast. The Carboniferous lowlands are generally less than 50 m in elevation though locally reach up to 200 m in the south-central part of the area. In contrast, the highlands of the Creignish Hills to the northwest have elevations locally exceeding 275 m and the North Mountain to the southeast has elevations of up to 230 m. A broad flat lowland area with a thick drift cover is located between Kingsville and McIntyre Mountain, and extends southeast along River Inhabitants.

HISTORICAL BACKGROUND

One of the earliest references to salt in the area was made by How (1869) who noted the presence of 4 salt springs issuing from conglomerate at the Salt Mountain at Whycocomagh approximately 25 km northeast of Kingsville.

The Cape Breton area was investigated for its salt and potash potential by Hayes (1931). Although no salt springs or indications of salt were found in the Kingsville area, many were described in the Whycocomagh, St. Patricks Channel, Orangedale, Bucklaw areas and near Dundee-West Bay. Drill exploration for salt was initiated in the Kingsville area between 1968 and 1971 by Domtar Limited (1968a) on the significant Bouguer gravity anomalies in the area.

GEOLOGY

The geology in the Kingsville area (Fig. 7-2) was described by Kelley (1967b) and Ferguson and Weeks (1950). The two highland ridges that border the area are the Creignish Hills to the northwest and North Mountain to the southeast. The Creignish Hills comprise Devonian and possibly older quartz monzonite, granodiorite and minor granite. These have intruded older, (possibly Hadrynian) George River Group rocks which comprise quartzo-feldspathic and micaceous quartz schist, quartz gneiss, limestone, quartzite, minor volcanic rocks and greywacke. The Lower Carboniferous Horton Group, Strathlorne-Ainslie Formation onlaps the older rocks of the highlands and occurs in a narrow outcrop band to the north near Glendale where the geology is obscured by thick drift cover. To the north of Kingsville, the Windsor Group is apparently overstepped by Mabou Formation strata which occur in a broad syncline in the central valley area and form hills with elevations of up to 200 m.

Windsor Group rocks outcrop both north and south of Maple Brook Syncline defined by the Mabou Formation strata. North Mountain, like the Creignish Hills, comprises pre-Carboniferous intrusives and Hadrynian George River Group metasedimentary rocks. These older rocks are overlain by a stratified section of sandstone, conglomerate and siltstone which Kelley (1967b) mapped as marginal facies of Horton Group and/or Windsor Group. This unit occurs in a narrow outcrop band between Big Brook and River Denys Station. This section is overlain with uncertain relationship by Windsor Group strata which occur in a southerly narrowing outcrop band beneath the Mabou Formation in the Maple Brook Syncline.

The salt drilling by Domtar Limited between 1968 and 1971 at Kingsville (Figs. 7-2 and 7-3) indicates the present geological maps require revision and reinterpretation at map borders. Interpolation between map sheets indicate a band of Horton Group outcrop in the salt deposit area. Previously unmapped faults may be used to explain this discrepancy. The contact between the Windsor Group (salt section) and the pre-Carboniferous to the west is interpreted as a fault (Fig. 7-2). Keppie (1976), based on radar imagery interpretation, indicated a major lineament paralleling River Inhabitants. This lineament may reflect the position of a major fault bounding the northeastern side of the salt mass. The Bouguer gravity anomaly coincident with the salt is oriented approximately north-south and parallels the western border fault (Fig. 7-1). Although the precise structural configuration of the salt mass is not clear, abnormal thickening is apparent along the axis of a complexly folded anticline (Figs. 7-2 and 7-4). A structural setting similar to that described by Giles (1981a) in the McIntyre Lake deposit area may be present in the Kingsville deposit. Further comparison will require detailed examination of the drill core from the Kingsville deposit.

In 1967 Domtar Limited (1968a) made a preliminary review of potential Maritime salt deposits and selected Kingsville, St. Peters and Seaview for diamond-drill testing the following year. The first hole at Kingsville (Kingsville No. 3) intersected salt at 376 m (1235 ft.) and was terminated in salt at 916 m (3006 ft.) (Fig. 7-3). Encouraged by the success of this hole an additional 4 holes were completed. Kingsville Nos. 4 and 5 were located in the immediate area of No. 3 and Kingsville Nos. 6 and 7 were drilled approximately 3 km south. Kingsville No. 4 was drilled 1220 m (4000 ft.) northwest of No. 3 and intersected salt at 494 m (1620 ft.), but was abandoned at 766 m (2512 ft.) due to drilling difficulties. Kingsville Nos. 6 and 7 are reported to have intersected "excellent salt" sections. In 1969 Domtar Ltd. drilled 5 more diamond-drill holes, all of which intersected salt (Kingsville Nos. 8-12).

Based on these data a solution mining test (KBW No. 1) was drilled near Kingsville No. 9 at the northern end of the salt body. This hole, completed at approximately 1220 m (4000 ft.) was fitted with an 8-5/8 inch production casing for the brining test that was begun near the bottom of the well. The testing indicated that brining was a satisfactory method to extract the salt.

GEOPHYSICS

The area in the vicinity of the Kingsville deposit is included on Nova Scotia Research Foundation Bouguer anomaly map Whycocomagh (Domtar, 1967) at a scale of two inches equals one mile (Figs. 7-1 and 7-5). The presence of salt indicated by the large circumscribed high amplitude (16 mGal) Bouguer gravity low has been established in diamond-drill holes.

GEOCHEMISTRY

Although salt springs have not been reported from the Kingsville area several were reported by Hayes (1931) to occur near Whycocomagh 20 km to the north and West Bay 12 km to the east. The presence of these salt springs indicates that salt probably underlies a large part of the River Denys Valley area. Chemical analyses of the salt at Kingsville are not as yet available for publication. The success of the brining test, however indicates the grade is sufficient for economic extraction.

ECONOMIC CONSIDERATIONS

The Kingsville deposit comprises halite with no potash reported. It is defined by 12 drillholes and coincides with a high amplitude Bouguer gravity low.

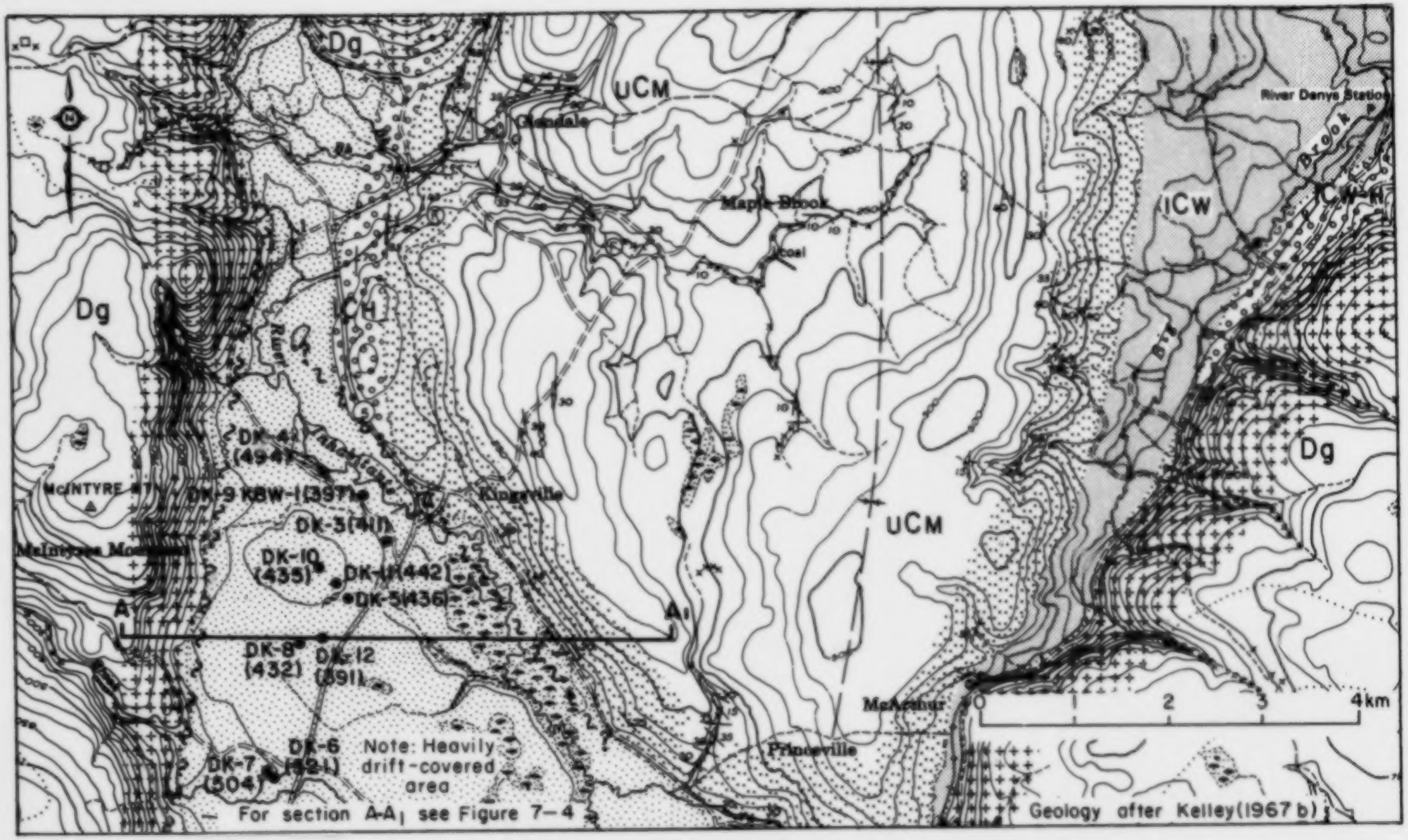
Domtar Ltd. (1968a) reported proven salt reserves, based on the drilling data, of approximately 28.6 million t (31.5 million tons). The company estimated probable reserves adjacent to the drilled area of approximately 1.04 billion t (1.15 billion tons). Domtar Limited has also considered the deposit for possible development of an underground salt cavern for petroleum storage. The Kingsville deposit is well suited for this use because it is situated approximately 20 km north of the ice free deep water port facilities on the Strait of Canso. Further developmental work on the deposit has been deferred.

MCINTYRE LAKE DEPOSIT

The McIntyre Lake deposit is located near McIntyre Lake which is situated approximately 7 km northeast of Port Hawkesbury, Inverness County (11F/11) (Figs. 1-10 and 7-6).

The area is readily accessible by highway and railway with Highway 4 and the mainline of the Canadian National Railroad passing within 1 km of the deposit. Excellent ice free deep water port facilities and the Point Tupper industrial area are situated between Point Tupper and Madden Cove on the Strait of Canso 10 km to the southwest. The small Port Hawkesbury regional airfield is situated 4 km north of Port Hawkesbury.

The terrain in the vicinity is typical of the Carboniferous Lowlands in southern Cape


Dg
uCM
lCW
lCW-H
CH
River Denys Station
Brook
Glendale
Maple Brook
coal
River
Kingsville
McINTYRE #1
McIntyre Mountain
DK-4 (494)
DK-9 KBW-1(397)
DK-3(411)
DK-10 (435)
DK-11(442)
DK-5(436)
DK-8 (432)
DK-12 (391)
DK-6 (521)
DK-7 (504)
A
A1
McArthur
Princeville
0
1
2
3
4km

Note: Heavily drift-covered area

For section A-A1 see Figure 7-4

Geology after Kelley(1967 b)

Figure 7-2. Geology in the vicinity of the Kingsville deposit, Inverness County.

LEGEND

UPPER CARBONIFEROUS

	MORIEN GROUP
uCm	Undivided: sandstone, conglomerate, shale and coal
	PICTOU GROUP
uCi	*INVERNESS FORMATION:* sandstone, shale and coal
	RIVERSDALE GROUP
uCr	Undivided: sandstone, conglomerate, shale and coal
	CANSO GROUP
uCCa-m	*MABOU FORMATION:* sandstone, siltstone and shale
uCCa	Undivided: sandstone, siltstone and shale
uCg	Gabbro, diabasic gabbro

LOWER CARBONIFEROUS

	WINDSOR GROUP
lCw	Undivided: siltstone, gypsum, anhydrite, halite and limestone
lCw-u	Upper: siltstone, gypsum, anhydrite and limestone
lCw-L	Lower: gypsum, anhydrite, siltstone and limestone
lCw-G	*GRANTMIRE FORMATION:* conglomerate and sandstone
lCw-m	Marginal basin beds (Weeks, 1954): conglomerate, sandstone and limestone
	HORTON and/or WINDSOR GROUP(S)
lCw-H	Marginal facies: conglomerate and sandstone
	HORTON GROUP
lCH-SA	*STRATHLORNE-AINSLIE FORMATION:* sandstone, conglomerate and shale
lCH	Undivided: conglomerate, sandstone and shale

DEVONO-CARBONIFEROUS

DCfb	*FISSET BROOK FORMATION:* mafic and felsic volcanic rocks, conglomerate and sandstone

DEVONIAN

DmL	*McADAM LAKE FORMATION:* conglomerate, sandstone, shale and tuff
Dg	Granite, diorite, granodiorite

CAMBRO-ORDOVICIAN

€Os	Undivided: conglomerate, grit, sandstone and shale

PROTEROZOIC

Pgd	gd, granodiorite; qd, quartz diorite; v, volcanics

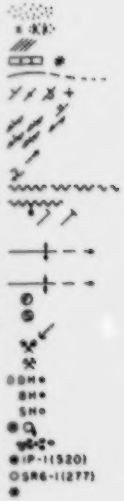
HADRYNIAN

Hg,gd	Granite, granodiorite
	FOURCHU GROUP
Hf	Undivided: volcanic and sedimentary rocks
	GEORGE RIVER GROUP
Hgr	Undivided: metasedimentary rocks

HADRYNIAN-DEVONIAN

H-D	Undivided (may include lCH)

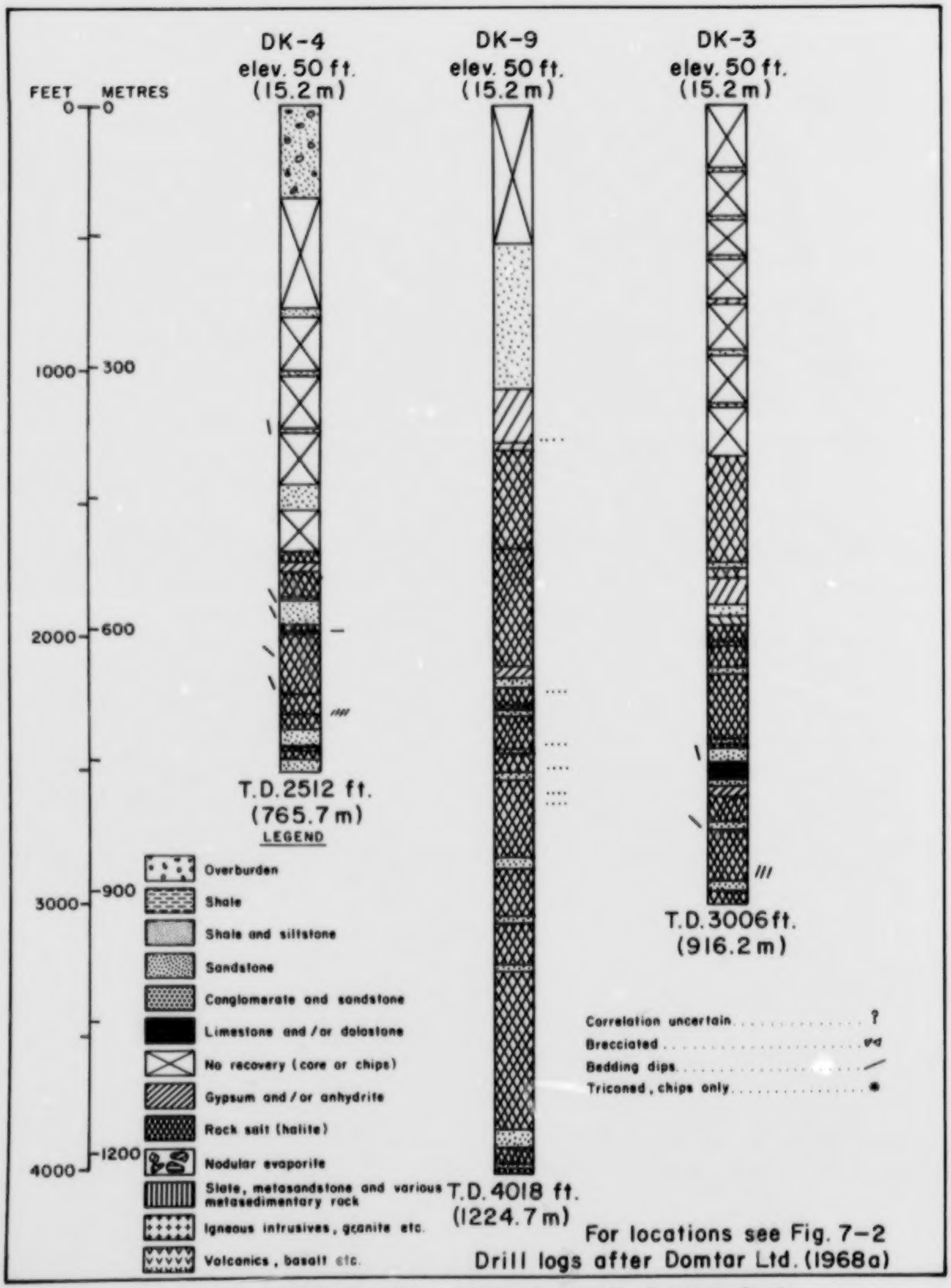
SYMBOLS



Heavily drift-covered area
Rock outcrop, area of outcrop
Limestone or dolomite outcrop (Faribault-Fletcher maps)
Gypsum outcrop
Geological boundary (defined, approximate, assumed)
Bedding, tops known (inclined, vertical, overturned, horizontal)
Bedding, tops unknown (inclined)
Schistosity (inclined, vertical, dip unknown)
Gneissosity (inclined, vertical)
Plunge of minor fold
Drag fold (arrow indicates plunge)
Fault (defined, approximate, assumed)
Fault (solid circle indicates downthrow side)
Joint (inclined, vertical)
Anticline (defined, approximate, arrow indicates direction of plunge)
Syncline (defined, approximate, arrow indicates direction of plunge)
Fossil locality
Spore sample
Glacial striae (ice flow direction known)
Gravel deposit
Quarry
Diamond-drill hole
Borehole
Sinkhole
Salt spring
Observed karst topography
Drillhole intersecting salt; number (depth to salt, metres)
Drillhole without salt; number (Total depth, metres)
Drillhole location precise to 150 m

MINERALS

Anhydrite	ah	Limestone	lst
Gypsum	gyp	Pyrite	py
Lead	Pb	Zinc	Zn
Celestite	Sr		


DK-4
elev. 50 ft.
(15.2 m)
DK-9
elev. 50 ft.
(15.2 m)
DK-3
elev. 50 ft.
(15.2 m)
FEET
METRES
0
0
1000
300
2000
600
3000
900
4000
1200
T.D. 2512 ft.
(765.7 m)
T.D. 4018 ft.
(1224.7 m)
T.D. 3006 ft.
(916.2 m)
LEGEND
Overburden
Shale
Shale and siltstone
Sandstone
Conglomerate and sandstone
Limestone and/or dolostone
No recovery (core or chips)
Gypsum and/or anhydrite
Rock salt (halite)
Nodular evaporite
Slate, metasandstone and various metasedimentary rock
Igneous intrusives, granite etc.
Volcanics, basalt etc.
Correlation uncertain ?
Brecciated
Bedding dips
Triconed, chips only

For locations see Fig. 7-2
Drill logs after Domtar Ltd. (1968a)

Figure 7-3. Drillhole profiles, Kingsville deposit, Inverness County.

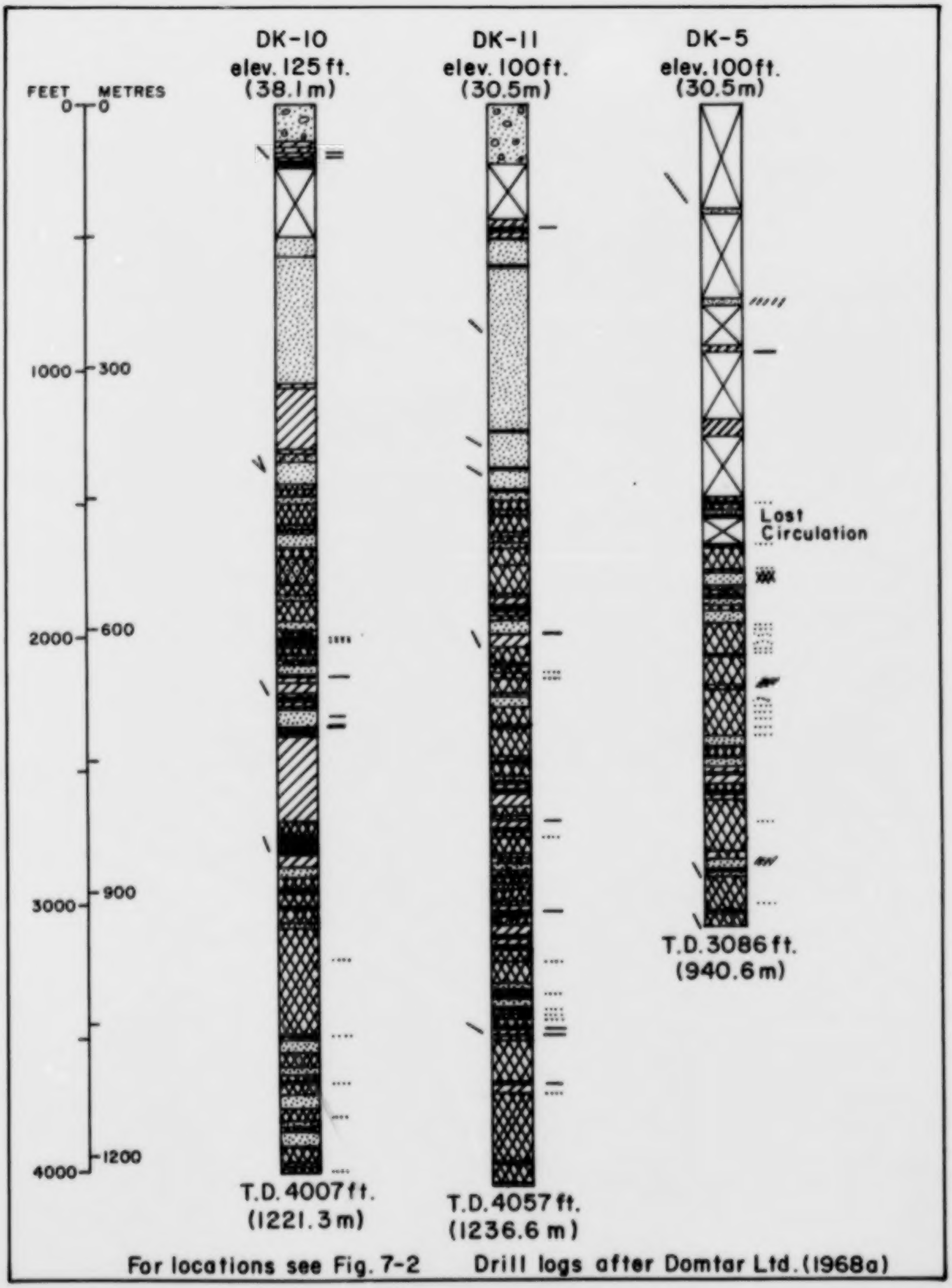

DK-10
elev. 125 ft.
(38.1 m)
DK-11
elev. 100 ft.
(30.5m)
DK-5
elev. 100 ft.
(30.5m)
FEET
METRES
0
0
1000
300
2000
600
3000
900
4000
1200
Lost Circulation
T.D. 4007 ft.
(1221.3 m)
T.D. 4057 ft.
(1236.6 m)
T.D. 3086 ft.
(940.6 m)
For locations see Fig. 7-2
Drill logs after Domtar Ltd. (1968a)

Figure 7-3. Continued.

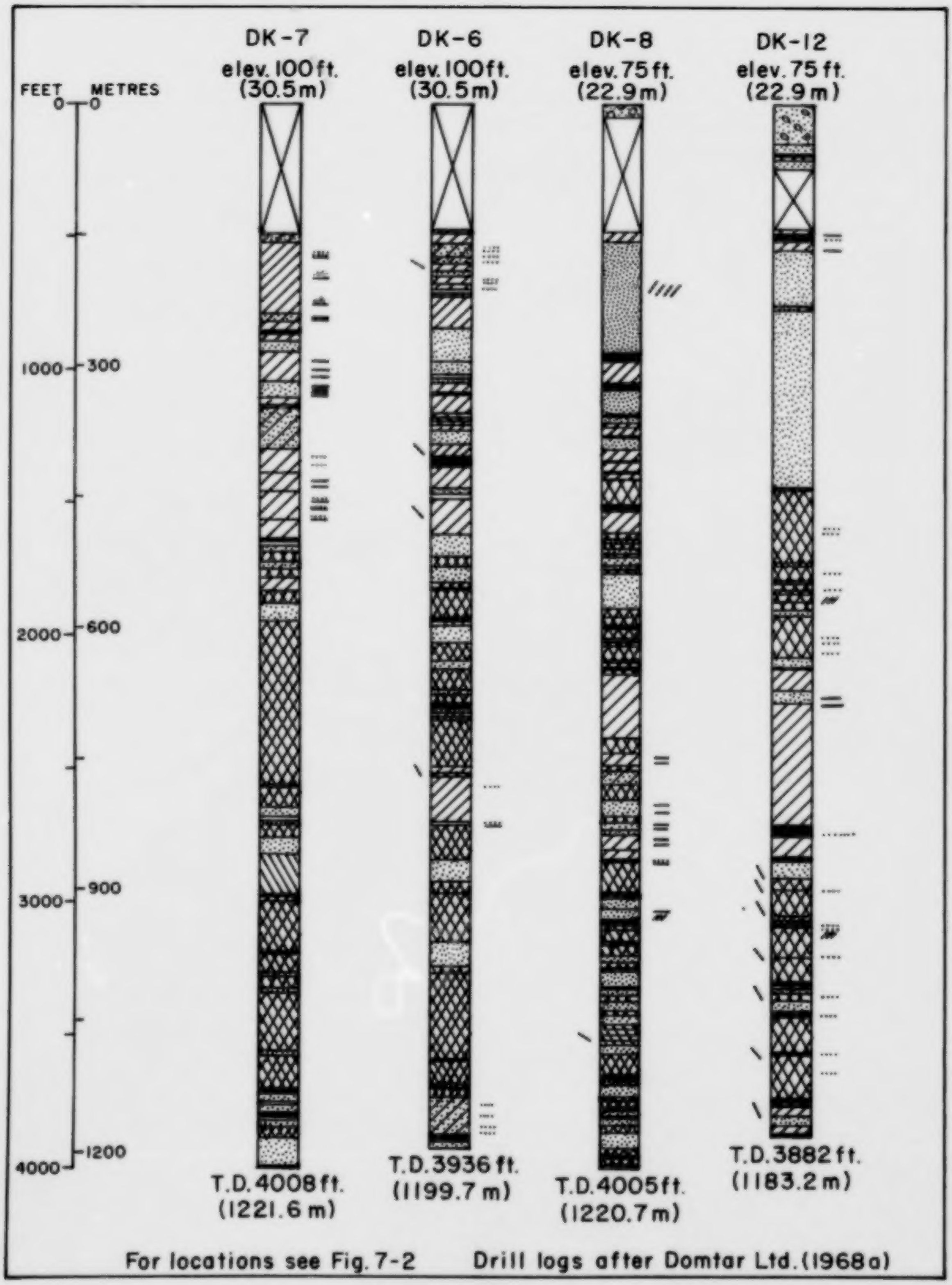

DK-7
elev. 100 ft.
(30.5 m)
DK-6
elev. 100 ft.
(30.5 m)
DK-8
elev. 75 ft.
(22.9 m)
DK-12
elev. 75 ft.
(22.9 m)
FEET
METRES
0
0
1000
300
2000
600
3000
900
4000
1200
T.D. 4008 ft.
(1221.6 m)
T.D. 3936 ft.
(1199.7 m)
T.D. 4005 ft.
(1220.7 m)
T.D. 3882 ft.
(1183.2 m)
For locations see Fig. 7-2
Drill logs after Domtar Ltd. (1968a)

Figure 7-3. Continued.

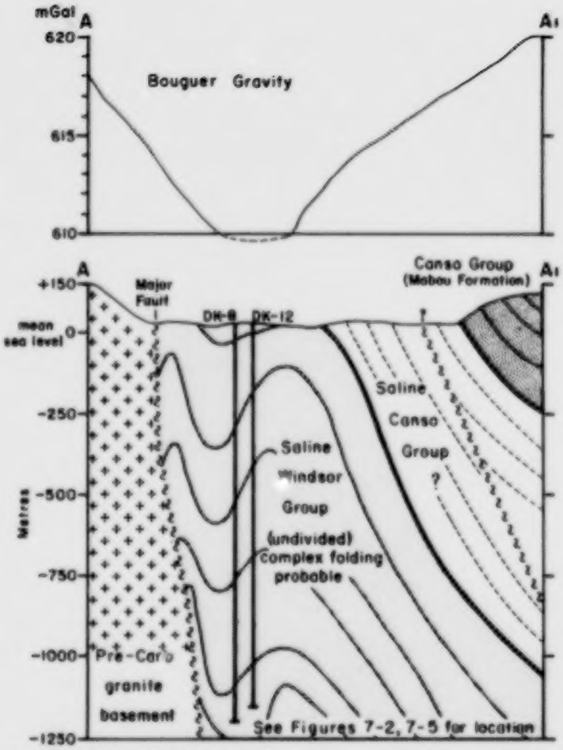

mGal
A
A₁
620
615
610
Bouguer Gravity
A
A₁
+150
mean sea level 0
-250
-500
-750
-1000
-1250
Metres
Major Fault
DK-8
DK-12
Canso Group (Mabou Formation)
Saline Canso Group
?
Saline Windsor Group (undivided) Complex folding probable
Pre-Carb granite basement
See Figures 7-2, 7-5 for location

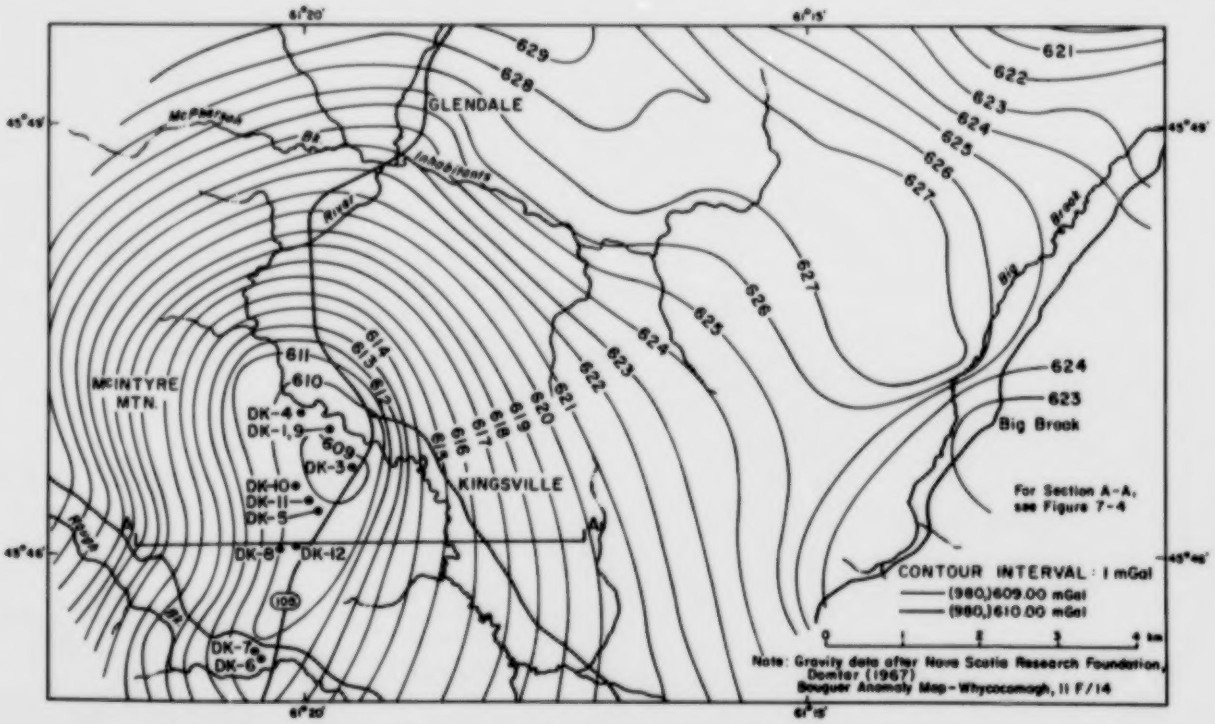
Figure 7-4. Geological and gravity cross-section, Kingsville deposit, Inverness County.

Breton Island. In this area elevations rarely exceed 125 m although in the bordering highlands, such as the Creignish Hills to the north and North Mountain to the northeast, elevations often exceed 200 m.

HISTORICAL BACKGROUND

Until recently, the McIntyre Lake area has received little attention directed at salt or potash exploration. The potash survey under Hayes (1931) did not locate salt springs in the immediate area of McIntyre Lake. Several were described, however in the Dundee-West Bay area located approximately 15 km northeast. Although salt springs were not located in the area by Ferguson (1946), the brooks traversing Windsor Group outcrop areas were reported to have a high degree of salinity. This was attributed to possible lenses of salt in the Windsor Group. The geology in the area is included in maps and reports by Ferguson (1946), Ferguson and Weeks (1950), Collins (1962) and Shea and Wallace (1962).

The potential for salt exploration in the area was not realized until the late 1960's when Bouguer gravity surveys outlined high amplitude gravity lows believed to be caused by substantial salt related structures (Fig. 7-1). Murphy Oil Company Limited and Northern Canadian Oils Limited followed up the initial studies by diamond-drill exploration programs in 1972 and 1974. This drilling established the presence of major salt deposit. Home Oil Canada Limited subsequently conducted further exploration and drilling in 1978 (Giles, 1981a). The McIntyre Lake deposit is being evaluated as a possible strategic petroleum reserve for the United States, with a view towards similar future


61°20'
61°15'
45°49'
45°46'
629
628
621
622
623
624
625
626
627
627
626
625
624
623
622
621
620
619
618
617
616
615
614
613
612
611
610
609
624
623
GLENDALE
McPherson Bk
Inhabitants River
Big Brook
Big Brook
McINTYRE MTN.
DK-4
DK-1,9
DK-3
DK-10
DK-11
DK-5
DK-8
DK-12
DK-7
DK-6
KINGSVILLE
105
For Section A-A, see Figure 7-4
CONTOUR INTERVAL: 1 mGal
(980,)609.00 mGal
(980,)610.00 mGal
0
1
2
3
4 km

Note: Gravity data after Nova Scotia Research Foundation, Domtar (1967)
Bouguer Anomaly Map - Whycocomagh, 11 F/14

Figure 7-5. Bouguer gravity anomaly map, Kingsville deposit, Inverness County.

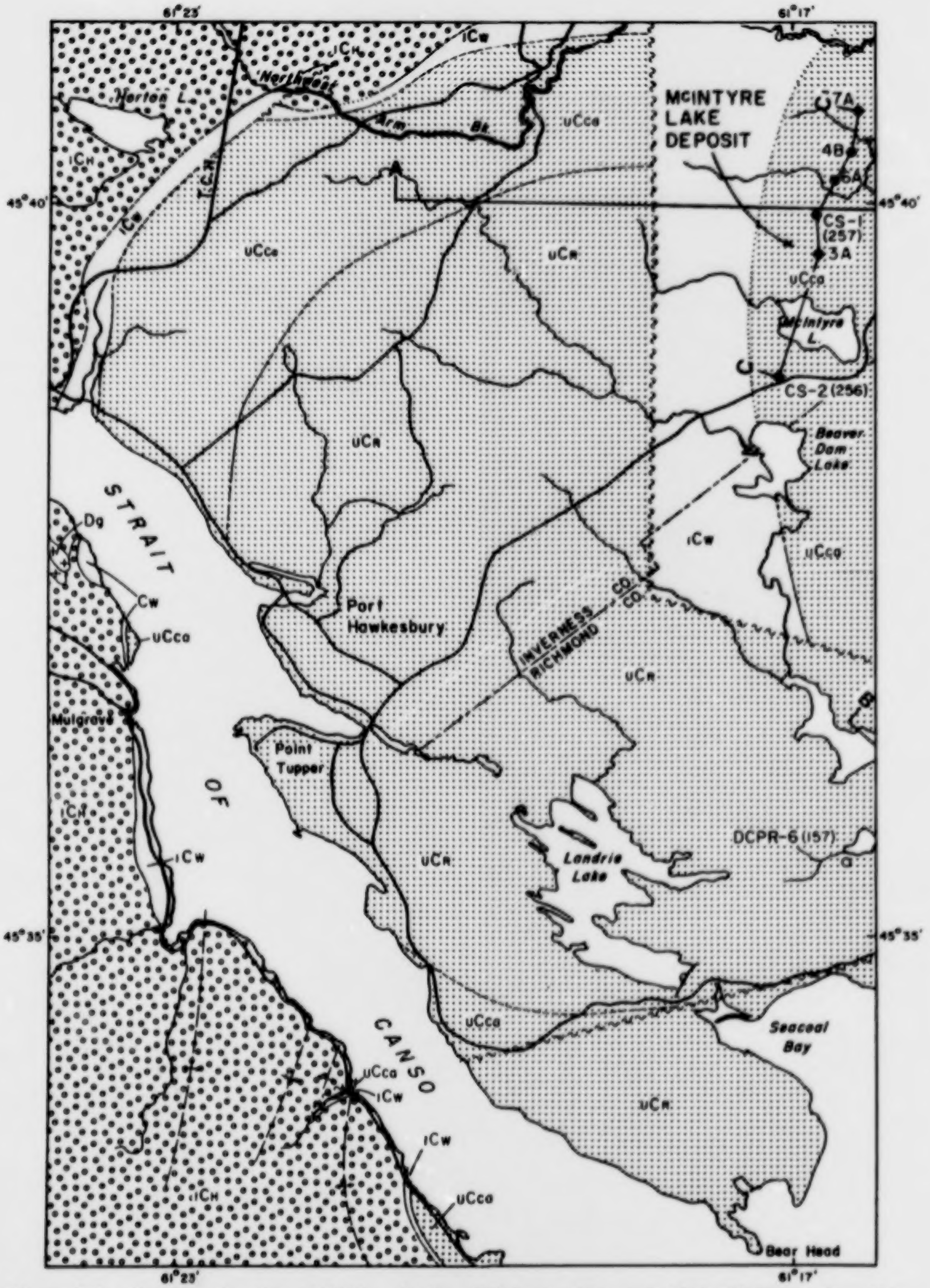
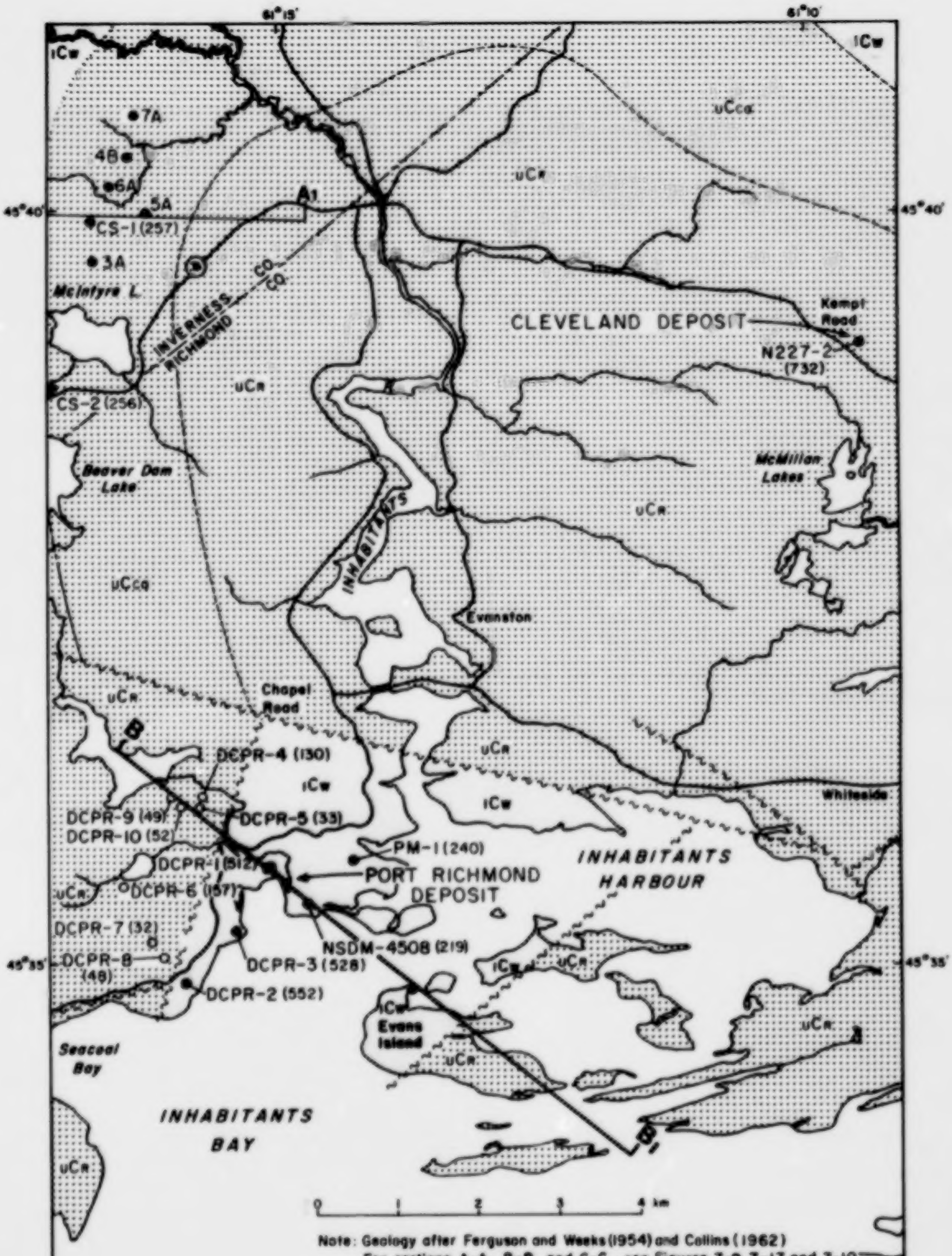

61°23'
61°17'
45°40'
45°35'
lCw
lCH
Northwest Arm Bk.
Horton L.
uCca
MCINTYRE LAKE DEPOSIT
7A
4B
5A
CS-1 (257)
3A
uCR
McIntyre L.
C
CS-2 (256)
Beaver Dam Lake
STRAIT OF CANSO
Dg
Cw
uCca
Port Hawkesbury
INVERNESS CO.
RICHMOND CO.
Mulgrave
Point Tupper
DCPR-6 (157)
a
Landrie Lake
Seacoal Bay
Bear Head

Figure 7-6. Geology in the vicinity of the McIntyre Lake and Port Richmond deposits, Inverness and Richmond Counties.


61°15'
61°10'
45°40'
45°35'
lCw
uCca
uCr
7A
4B
6A
5A
A1
CS-1 (257)
3A
McIntyre L.
INVERNESS CO.
RICHMOND CO.
CLEVELAND DEPOSIT
Kempt Road
N227-2 (732)
CS-2 (256)
Beaver Dam Lake
McMillan Lakes
INHABITANTS
Evanston
Chapel Road
B
DCPR-4 (130)
DCPR-9 (49)
DCPR-10 (52)
DCPR-5 (33)
PM-1 (240)
DCPR-1 (512)
PORT RICHMOND DEPOSIT
DCPR-6 (157)
DCPR-7 (32)
DCPR-8 (48)
NSDM-4508 (219)
DCPR-3 (528)
DCPR-2 (552)
INHABITANTS HARBOUR
Whiteside
Evans Island
Seacoal Bay
INHABITANTS BAY
B1
0 1 2 3 4 km

Note: Geology after Ferguson and Weeks (1954) and Collins (1962)
For sections A-A$_1$, B-B$_1$ and C-C$_1$, see Figures 7-9, 7-17 and 7-10
For legend see Figure 7-2

Figure 7-6. Continued.

development as a Canadian reserve and as a trans-shipment complex.

GEOLOGY

The geology in the immediate vicinity of the McIntyre Lake deposit (Fig. 7-6) has been described and mapped by Ferguson (1946) as part of the Mulgrave map sheet (11F/11W). The adjoining map area (11F/14) to the north was described and mapped by Kelley (1967b) and the eastern half of NTS 11F/11 was described and mapped by Collins (1962). The Port Hawkesbury-Strait of Canso area is the location of one of the thicker sections of Carboniferous rocks. The major structure in the area is a large syncline, defined by the Windsor Group and younger Canso and Riversdale Groups. This major structure is complicated by several major faults associated with or bounding in part outcrop areas of Windsor Group. Two such areas are McIntyre Lake and Port Richmond. In the western and northwestern margins of the area the Windsor Group outcrop areas are extremely narrow, the strata steeply dipping, and locally faulted and overturned. The Canso Group rocks overlie the Windsor Group in onlap relationship (Ferguson, 1946). Although there are some discrepancies in units from map to map, the broad outcrop area of Windsor Group rocks mapped to the north of McIntyre Lake are considered to extend into the adjoining map area.

The Horton outcrop belt on the eastern side of the Creignish Hills (Fig. 1-10) may be terminated by north-northwestward trending faults extending from the McIntyre Lake area. One of these faults appears to coincide with the River Inhabitants lineament of Keppie (1976) and define the southern border of the Maple Brook Syncline (Fig. 7-2). A second fault, on the western border of the Kingsville deposit, may extend through the Queensville area into the fault defining the western border of the McIntyre Lake structure (Fig. 7-6). The eastern border of the McIntyre Lake structure appears to be a relatively undisturbed section from the Windsor Group through the Canso and Riversdale Groups. Drilling indicates the Canso Group outcrop belt may extend farther to the west than previously mapped. In addition, evaporites including anhydrite and halite probably occur in the Canso section. If the Windsor Group contact with the Canso Group is conformable then the large scale onlap described in marginal areas (such as north of Kingsville) is very local or suspicious. Low angle faulting and complex folding may have produced these abnormal contacts. The extension of Ferguson's (1946) Canso and Riversdale outcrop belts into adjoining map areas is not consistent, particularly near North Mountain and West Bay (Fig. 7-1). Kelley (1967b) indicated the Maple Brook Syncline should extend southward into the West Bay Road area, but outcrop there was mapped as Windsor Group by Ferguson (1946). The Windsor outcrop belt between the Mabou Formation and pre-Carboniferous basement of North Mountain narrows rapidly southward and is apparently onlapped by the Canso Group (Mabou Formation).

Collins (1962) indicated a faulted contact with Canso Group rocks against the southeastern and southern borders of North Mountain. The extension of this fault into the Mulgrave map area was not recognized by Ferguson (1946). Keppie (1976) noted a lineament through West Bay parallel with the trend of North Mountain and a fault mapped by Collins (1962).

The southern border of the McIntyre Lake structure is also defined by a fault. This fault trends slightly south of east and extends from near the Inverness-Richmond Counties line into the Inhabitants Harbour area where it defines the northern border of the Port Richmond structure.

The surface expression of the McIntyre Lake structure, as presently mapped, may be interpreted as anticlinal with bounding faults to the west and south and possibly a relatively normal succession towards an adjacent syncline to the east.

Field mapping in the McIntyre Lake area and subsequent drilling by Murphy Oil Canada Limited et al. (Hale, 1972) indicated a complexly folded structural configuration. This structure, based upon the gravity and subsurface data, may be grossly interpreted as a diapiric anticline similar in some respects to those occurring in the Cumberland area and near Mabou.

NCO Canso Strat No. 1 (CS-1) well was the first drillhole put down in the McIntyre Lake structure (Figs. 7-6 and 7-7) (Hale, 1972). It was drilled in 1972 by Northern Canadian Oils Limited and Murphy Oil Company Limited. The hole intersected overburden to 55 m (180 ft.) and Windsor Group comprising brecciated clay-shale, gypsum with several thick massive highly permeable intervals of limestone to 256.6 m (842 ft.). Coring in the hole began at a depth of 96 m (315 ft.). A major salt section was then penetrated to the final total depth of 670.6 m (2200 ft.). Fairly thick anhydrite intervals were reported at 526.4-528.7 m (1727-1734.5 ft.), 531.6-563 m (1744-1847 ft.), and 580-582 m (1902-1909 ft.). Traces of potash salts were indicated throughout the salt sections. The dip in the main salt section was reported to range from 60° to 70°.

Based upon the encouraging results of Canso Strat No. 1, a second hole, Canso Strat No. 2 (CS-2) was spudded in 1974 approximately 2.2 km (1.4 miles) south of No. 1, in the area of McIntyre Lake and Beaver Dam Lake (Figs. 7-6 and 7-8). In summary, Canso Strat No. 2 (Hale, 1974) encountered the following section: overburden to 27.4 m (90 ft.); gypsum and clay to 76.2 m (250 ft.) where coring was begun; anhydrite with minor gypsum to 136.2 m (447 ft.); dark limestone and shale to 189 m (620 ft.); shale, gypsum and limestone breccia to 255 m (836 ft.) where the salt section was then entered. The exact structural nature and interrelations of the section from 255 m (836 ft.) to the final total depth of 916.5 m (3007 ft.) is not clear. Two fault or shear zones are reported to occur in this interval; the first at 559-559.9 m (1834-1837 ft.) and the second at 898 m (2946-2947 ft.). In addition, the section comprises a heterogeneous lithologic suite including thick intervals of interstratified limestone, anhydrite and claystone-shale (Fig. 7-8). This section

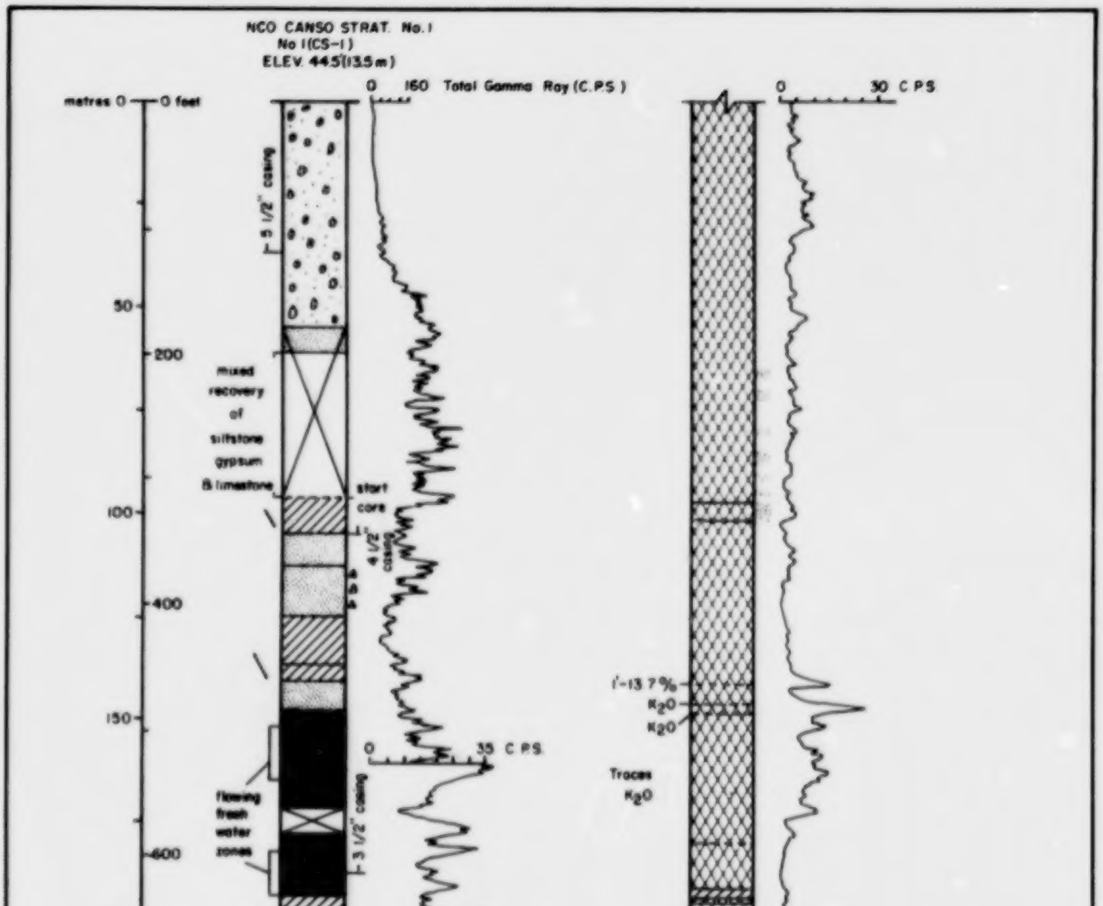
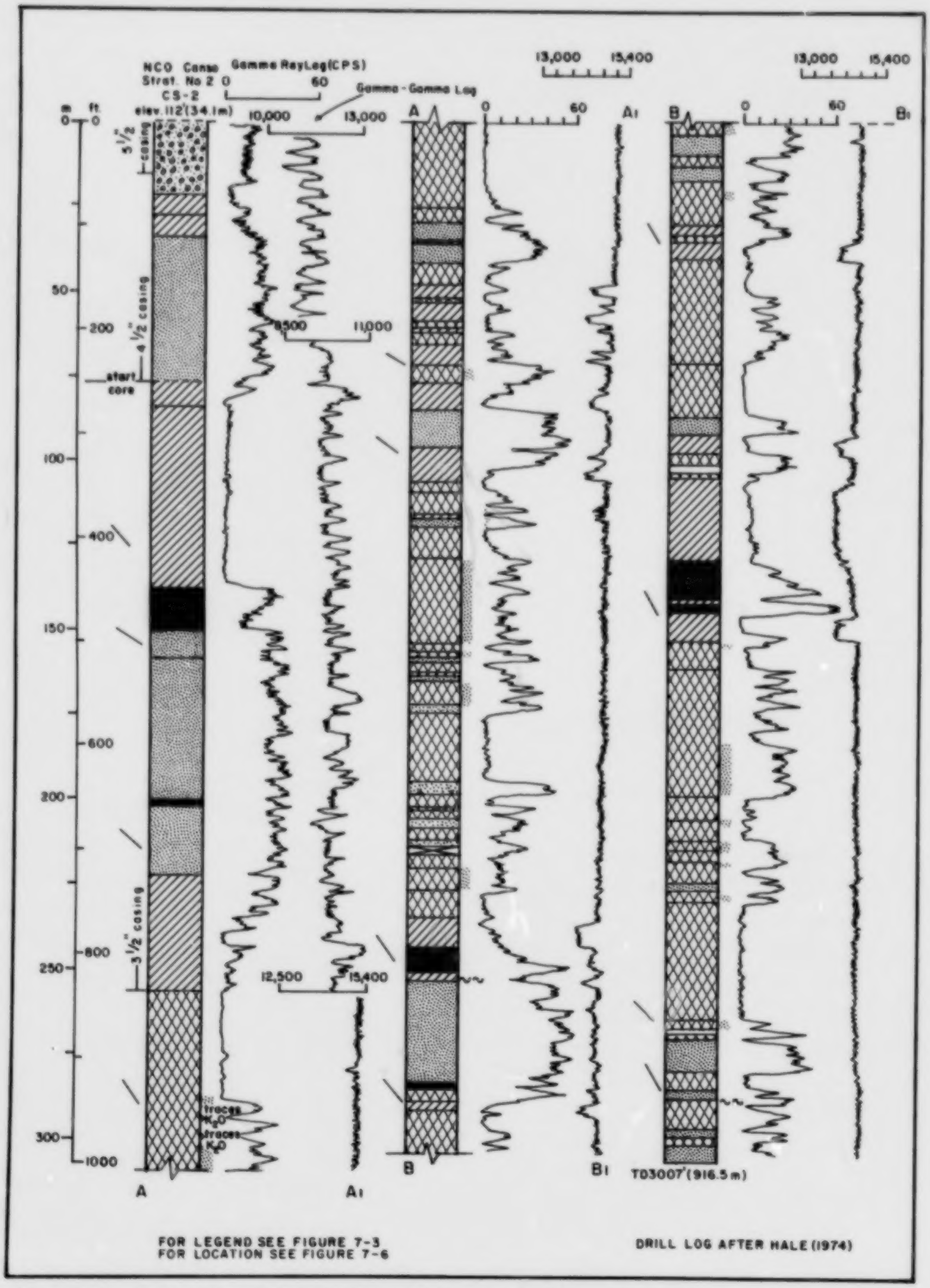

NCO CANSO STRAT. No. 1
No 1(CS-1)
ELEV. 44.5'(13.5 m)
0 160 Total Gamma Ray (C.P.S.)
metres 0
0 feet
50
200
100
400
150
600
200
800
250
300
1000
1100
5 1/2" casing
mixed recovery of siltstone gypsum & limestone
start core
4 1/2" casing
flowing fresh water zones
0 35 C.P.S.
3 1/2" casing
2 3/4" casing
K2O
K2O
ʃ'-14.1 % K2O
K2O reported no analysis
0 25 C.P.S.
0 30 C.P.S.
ʃ'-13.7 %
K2O
K2O
Traces K2O
Traces K2O
Traces K2O
T.D. 2200'(670.6 m)
DRILL LOG AFTER HALE (1972)
FOR LEGEND SEE FIGURE 7-3
FOR LOCATION SEE FIGURE 7-6

Figure 7-7. Drillhole profile NCO Canso Strat No. 1, McIntyre Lake deposit, Richmond County.

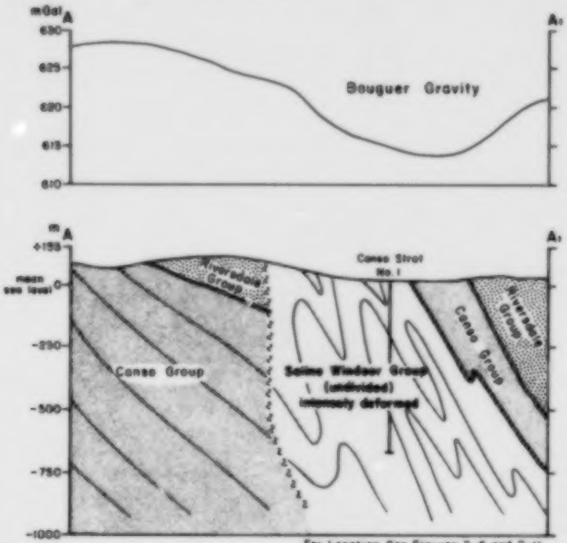

NCO Canso Strat. No 2
CS-2
elev. 112'(34.1m)
Gamma RayLog(CPS)
0
60
Gamma-Gamma Log
10,000
13,000
9,500
11,000
12,500
15,400
13,000
15,400
m
ft.
0
50
100
150
200
250
300
200
400
600
800
1000
5 1/2" casing
4 1/2" casing
3 1/2" casing
start core
traces K_2O
traces K_2O
A
A1
B
B1
TD3007'(916.5m)

FOR LEGEND SEE FIGURE 7-3
FOR LOCATION SEE FIGURE 7-6

DRILL LOG AFTER HALE (1974)

Figure 7-8. Drillhole profile NCO Canso Strat No. 2, McIntyre Lake deposit, Richmond County.

appears to be different from that reported in the Canso Strat No. 1 test and is probably the result of structural complexity related to faulting and folding (Fig. 7-9). Major, locally brecciated, claystone and anhydrite intervals occur at 356-472 m (1167-1548 ft.). Limestone layers were first reported at 502-551 m (1647-1807 ft.) and extend to 592 m (1942 ft.). Claystone and anhydrite rocks with halite continue to 682 m (2237 ft.) and resume at 698-840 m (2289-2756 ft.). Limestone reappears at 740-755 m (2427-2477 ft.). Halite with claystone breccia reappears at 875 m (2870 ft.) to the bottom of the hole at 916.5 m (3007 ft.). Bedding dips throughout the section are variable, but generally very steep at 60°-80°. Details of NCO Canso Strat Nos. 1 and 2 are included in the well history reports by Hale (1972, 1974).
leave 30 lines for Fig. 7-9



For Location See Figures 7-6 and 7-11

Figure 7-9. Geological and Bouguer gravity cross-section, McIntyre Lake deposit, Inverness County.

Hale (1972, 1974) recognized the following intervals of suggested lithologic correlation: the "Reefoidal limestone" section, 152-193 m (499-632 ft.) in No. 1 with the "fractured limestone" section, 137-175 m (449-575 ft.) in No. 2; "Black Anhydrite", 532-563 m (1744-1847 ft.) in No. 1 and 356-392 m (1167-1287 ft.) in No. 2. More recently detailed examination of the stratigraphy of the NCO drillholes and later drillholes by Home Oil et al. have provided greater insight into the probable structural configuration (Giles, 1981a, Figs. 7-6 and 7-10). Serious consideration must be given to problems encountered historically in the interpretation of Windsor Group salt geology in Nova Scotia. Moderate to steep dips are described in both holes, but correlation requires minimal dips. Salt structures in the Cumberland area were initially interpreted as little disturbed relatively simple anticlines. Subsequent workers including Evans (1972) and deep petroleum wells have indicated that the simplicity was only superficial. In fact, the structures were major anticlinal diapirs, with complex internal structure.

GEOPHYSICS

The area in the vicinity of the McIntyre Lake deposit is included on several gravity survey maps. The Nova Scotia Research Foundation (1967c, 1971) conducted gravity surveys in the area. The Nova Scotia Research Foundation Gravity Survey (1971), gravity map was used by Airborne Geophysical Surveys Ltd. in a gravity interpretation for Murphy Oil Company Limited (Galeski, 1971). In 1970 a gravity survey by Overland Exploration Services (1969) Ltd. was conducted for Murphy Oil Company Limited (Salt, 1970).

A distinct, high amplitude, Bouguer gravity outlined in the Port Richmond deposit area extends as a trough, into the McIntyre Lake area (Figs. 7-11). The western border of the anomaly is highly linear and is parallel with the northwestern border of North Mountain. The latter border is inferred to be a major fault. The presence and possible extension of this fault toward Port Hawkesbury is speculative.

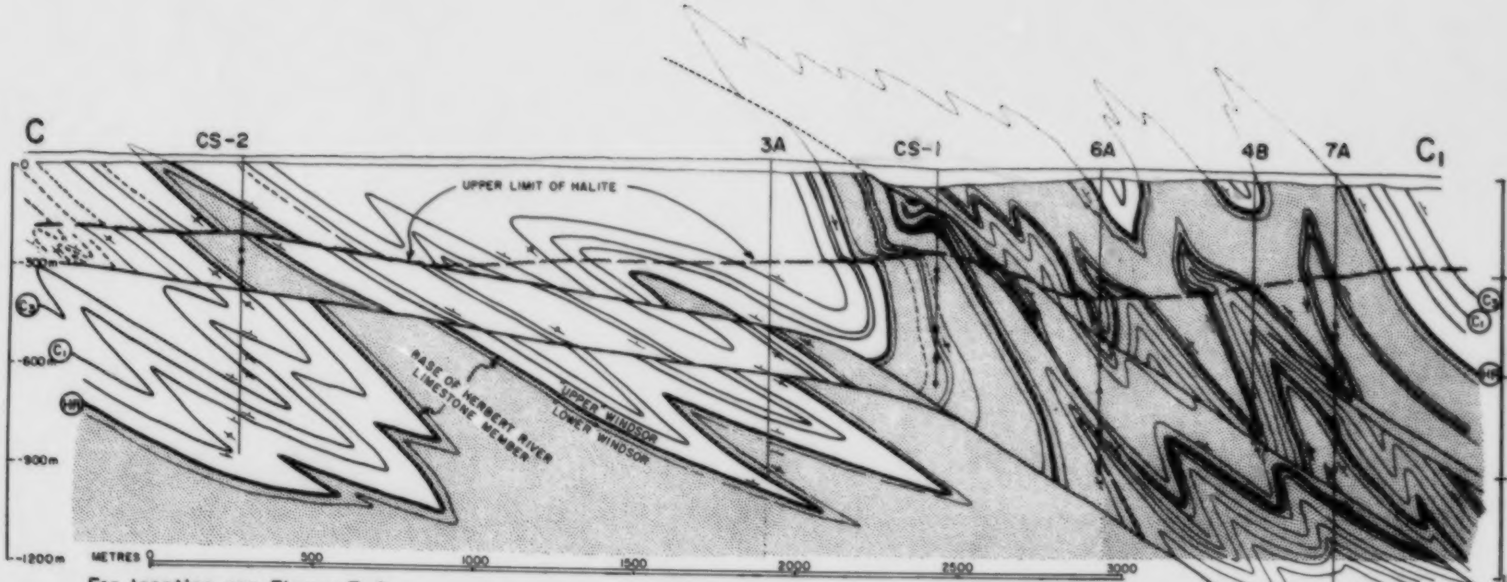
Geophysical-mechanical logging was carried out in both NCO Canso Strat Nos. 1 and 2 by the Nova Scotia Research Foundation. In Canso Strat No. 1 total gamma ray and caliper logs were completed and in Canso Strat No. 2 total gamma ray, micro-caliper and gamma-gamma (density) logs were completed (Figs. 7-7 and 7-8). These logs are useful in establishing lithology and correlation especially in the uncored parts of drillholes. Rock density measurements (Table 7-1) from selected core samples were done by the Nova Scotia Research Foundation as an aid to interpreting the geophysical logs.

GEOCHEMISTRY

Salt springs have not been described in the area. Chemical analyses on selected salt and potash samples and intervals were carried out by Core Laboratories Canada Ltd. on NCO Canso Strat No. 1 (Table 7-2). More detailed analyses were done on the NCO Canso Strat No. 2 drill core (in Hale, 1972) (Table 7-3 and notes on methods in Appendix 2) at intervals of 3.048 m (10 ft.) from 255.1 m (837 ft.) to the final total depth of 916.5 m (3007 ft.). The salt varies in purity ranging from 80-95% NaCl with an average of approximately 85%. Potash is present in minor amounts with analyses rarely exceeding 0.1% K.

ECONOMIC CONSIDERATIONS

The McIntyre Lake deposit comprises halite with local thin (less than 30 cm) potash salt zones with K_2O analyses of up to 14%. A significant Bouguer gravity anomaly coincident with an outcrop area of Windsor Group, together with the drill data available, indicate the presence of a potentially large salt deposit. The Canso Strat No. 1 hole intersected salt at 256.6 m (842 ft.) and was abandoned in salt at 671 m (2200 ft.). An accurate estimate of proven reserves is pending the completion of further exploration work by Home Oil et al. who have been exploring for potential development of solution mined underground storage structures. The project, although planned for a United States strategic


C
CS-2
3A
CS-1
6A
4B
7A
C_1
UPPER LIMIT OF HALITE
BASE OF HERBERT RIVER LIMESTONE MEMBER
UPPER WINDSOR
LOWER WINDSOR
C_3
C_1
HR
0
300m
600m
900m
1200m
METRES 0
500
1000
1500
2000
2500
3000

For location see Figure 7-6

Figure after Giles (1981a)

Figure 7-10. Stratigraphic and structural section C-C_1 showing distribution of Lower (screened) and Upper Windsor strata, and potash occurrences (black dots); HR, C_1 and C_3 refer to the Herbert River, C_1 and C_3 limestone members respectively. Form lines in heavy black indicate carbonate marker horizons; other form lines reflect correlative anhydrite-carbonate-siltstone-halite contacts.

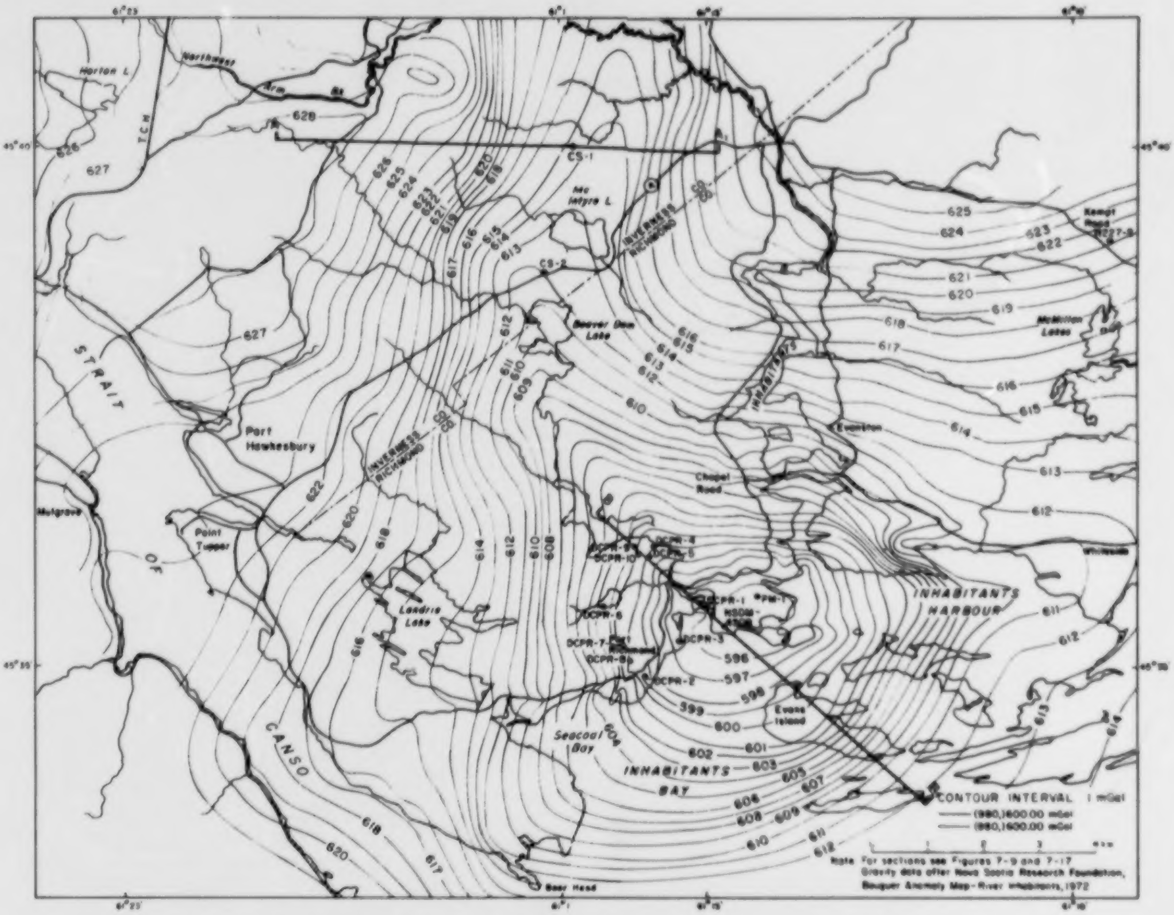

Horton L.
Northwest Arm
CS-1
CS-2
McIntyre L.
INVERNESS RICHMOND
Beaver Dam Lake
STRAIT OF CANSO
Port Hawkesbury
Point Tupper
Mulgrave
Landrie Lake
Chapel Road
Evanston
INHABITANTS
INHABITANTS HARBOUR
INHABITANTS BAY
Seacoal Bay
Evans Island
Kempt Road
McMillan Lakes
Whiteside
DCPR-1
DCPR-2
DCPR-3
DCPR-6
DCPR-10
Bear Head
CONTOUR INTERVAL 1 mGal
(980,)600.00 mGal
(980,)600.00 mGal
km
Note For sections see Figures 7-9 and 7-17
Gravity data after Nova Scotia Research Foundation,
Bouguer Anomaly Map-River Inhabitants, 1972

Figure 7-11. Bouguer gravity anomaly map, McIntyre Lake and Port Richmond deposits.

petroleum reserve could be expanded for future use as a Canadian reserve and/or petroleum trans-shipment facility. In addition, the salt deposit could supply a petrochemical industry. The Strait of Canso is an excellent ice free deep water port capable of handling VLCC (Very Large Crude Carriers) ships. This together with the close proximity of the McIntyre Lake deposit are encouraging for future development possibilities.

MALAGAWATCH DEPOSIT

The Malagawatch deposit is situated along the western shore of Bras d'Or Lake near Malagawatch, Inverness County (NTS 11F/15, Figs. 1-10, 7-1 and 7-12). Malagawatch is located approximately 40 km northeast of Port Hawkesbury and 20 km southeast of Whycocomagh. The area is accessible by paved and unpaved roads connected with Highways 104 and 105. The Canadian National Railway mainline between Port Hawkesbury and Sydney is situated 10 km to the west.

The topography in the area is dominated by the North Mountain which rises abruptly to 230 m. The Carboniferous Lowlands are largely submerged beneath Bras d'Or Lake and rarely have elevations that exceed 50 m.

HISTORICAL BACKGROUND

Although salt springs are not known in the Malagawatch area, several have been reported by Hayes (1931) in the Orangedale, Whycocomagh and West Bay areas (Figs. 1-10 and 7-1). The recent discovery of salt and potash near Malagawatch was complicated as well as serendipity (Dekker, 1982a). Chevron Standard Ltd. (1978) unexpectedly encountered light crude oil in base metal exploration drilling near Malagawatch (Fig. 7-12). The area became a petroleum prospect that was drilled in 1980 under a joint venture between Chevron Standard Ltd. and Irving Oil Company Ltd. The third well drilled was located near Malagawatch Point and unexpectedly intersected a significant section of salt and potash. The Malagawatch area then became a promising potash prospect that encouraged further potash exploration in the central part of Cape Breton Island by Chevron Standard Ltd. and Noranda Exploration Co. Ltd.

Table 7-1. Rock density determinations, NCO Canso Strat No. 1, McIntyre Lake deposit, Inverness County.***

Sample Depth (ft.)	Rock type	Medium H_2O or Oil	Saturated Density(S)	"Dry" Density(D)	"Grain"* Density	(S-D)	Porosity**
1850	Anhydritic Claystone	H_2O	2.57	2.53	2.64	0.04	0.0416
1959	Anhydrite	H_2O	2.93	2.92	2.94	0.01	0.0101
1973	Dark salt	Oil	2.16	2.16	2.16	0	0
1993	Light salt	Oil	2.13	2.12	2.14	0.01	0.0101
2977	Green-grey Anhydrite	Oil	2.404	2.378	2.452	0.026	0.027
2982	Bed Claystone	Oil	2.422	2.406	2.455	0.016	0.016

NOTES: *density in g/cm^3

** $\frac{D}{1-(S-D)}$

Procedure used in density measurements
a) heated sample for 3 hours in oven at 110°C to completely dry
b) completely filled sample with water or oil under vacuum
c) weighed samples after each preparation
d) density of 12R7M Oil 0.8603 g/cm at room temperature

***Data by Nova Scotia Research Foundation (in Hale 1974)

Detailed information regarding the geology of the salt and potash in the Malagawatch deposit has only become available after the preparation of this report. Detailed descriptions of the stratigraphy and structure of the salt and potash in the area therefore are not included in this report. Dekker (1982b) reported that the stratigraphy and structure of the Windsor Group at Malagawatch were generally similar to those in the McIntyre Lake deposit area. Potash occurred at three stratigraphic levels (Fig. 7-13), one in Cycle 2 (upper potash) and two near the top of Cycle 1 (middle and lower potash) with the lower potash the major economic horizon (Table 7-4). For further information the reader is directed to the excellent summary report on the Malagawatch Project by Dekker (1982b).

ORANGEDALE DEPOSIT

The Orangedale deposit is situated near Orangedale in central Cape Breton Island (NTS 11F/14, Figs. 1-19, 7-1 and 7-12). Orangedale is located approximately 10 km south of Whycocomagh which is located approximately 45 km northeast of Port Hawkesbury.

The area is readily accessible by a series of all weather paved and gravel roads connected with Highway 105. The Canadian National Railway Mainline between Port Hawkesbury and Sydney passes through Orangedale.

The topography in the area is typical of the Carboniferous Lowlands where elevations rarely exceed 50 m. Highlands with elevations exceeding 275 m form the northwestern and southeastern borders to the Lowlands.

HISTORICAL BACKGROUND

Salt springs have been known in the area for at least 100 years. Systematic exploration for salt and potash was not recorded until Hayes (1931) described the area as part of a regional survey. Although drill exploration was not a part of this study, salt springs were described from nearby localities including Bucklaw, Baddeck, Whycocomagh, Orangedale and Dundee. Exploration activity was not renewed until 1977 when Noranda Exploration Co. Ltd. (1977, 1978 and 1979), following geophysical and geochemical surveys, drilled an exporation hole (N225-1) near Wilburn approximately midway between Orangedale and Whycocomagh (Fig. 7-12). This hole was located on the northeastern flank of a large Bouguer gravity low (Fig. 7-14) and intersected a highly brecciated salt bearing section from a depth of approximately 610-892 m (2000-2927 ft.). Potash salts were not reported from this drillhole.

Following the reports of significant potash intersected in the Malagawatch area by Chevron Standard Ltd. (1978) and Irving Oil Ltd. exploration was expanded and resulted in the drilling of a series of 4 more holes across the Bouguer gravity low. Detailed descriptions of the stratigraphy, structure and quality of the salt and potash are not available at this time (Noranda, 1981). The stratigraphy and structure of the Windsor Group appears to be generally similar to that described in the Malagawatch deposit area by Dekker (1982b). Descriptions and interpretations of geological, geochemical and geophysical surveys in the area prior to the exploration drilling are included in reports by Fundy Geoservices Ltd. (1978 and 1980).

Table 7-2. Chemical analyses, NCO Canso Strat No. 1, McIntyre Lake deposit, Inverness County.*

File Number	Interval (Feet)	Water Insolubles	Acid Insolubles
2302-01	1980-1990	12.91%	
2302-02	1990-2000	36.52%	19.84%
2302-03	2000-2010	28.57%	
2302-04	2010-2020	42.86%	
2302-05	2020-2030	18.55%	
2302-06	2030-2040	3.61%	
2302-07	2040-2050	4.62%	
2302-08	2050-2060	11.99%	
2302-09	2060-2070	33.47%	15.83%
2302-10	2070-2080	18.05%	
2302-11	2080-2090	16.91%	
2302-12	2090-2100	15.48%	
2302-13	2100-2110	14.69%	
2302-14	2110-2120	29.49%	
2302-15	2120-2130	16.21%	
2302-16	2130-2140	4.68%	
2302-17	2140-2150	20.31%	
2302-18	2150-2160	13.35%	
2302-19	2160-2170	16.80%	
2302-20	2170-2180	7.55%	
2302-21	2180-2190	1.04%	
2302-22	2190-2200	8.46%	

* Core Laboratories Canada Ltd. (in Hale, 1972) reports submitted to Nova Scotia Department of Mines and Energy.

PORT RICHMOND DEPOSIT

The Port Richmond deposit is situated along the western shore of Inhabitants Harbour near Port Richmond, Richmond County (Figs. 1-10, 7-1 and 7-6). Port Richmond is located approximately 8 km east of Port Hawkesbury on the Strait of Canso (NTS 11F/11).

The area is readily accessible by all weather roads connected with Highway 4 at Port Hawkesbury and Cleveland. The Canadian National Railway is situated approximately 2 km north of the deposit area.

Topography in the vicinity of the Port Richmond deposit is typical of the Carboniferous Lowlands in southern Cape Breton. In these Lowlands elevations rarely exceed 100 m.

HISTORICAL BACKGROUND

Exploration for salt in the Strait of Canso area was initiated in the Port Richmond area by Dow Chemical Company of Canada, Limited and Dew Mining Corporation Limited in 1967. Interest in the Port Richmond area was stimulated by the presence of a high amplitude negative Bouguer gravity anomaly located by the Nova Scotia Research Foundation (1965a). The anomaly was outlined in greater detail by subsequent gravity surveys and two diamond-drill holes drilled by Dow in 1967. By 1972 5 deep exploration holes intersected significant salt sections. A series of 7 shallow holes were also drilled to obtain structural and stratigraphic information. In 1973 a brining well DCPR-11 was drilled at the PR-1 location and test caverns were developed between 1973 and 1976. In 1975 a second brining well was drilled and a test cavern developed between 1975 and 1976. Further development at the Port Richmond deposit is presently in a state of deferment (Dow Chemical of Canada Ltd., 1975).

GEOLOGY

Geological mapping in the vicinity of the Port Richmond deposit has been carried out in surveys

Table 7-3. Chemical analyses, NCO Canso Strat No. 1, McIntyre Lake deposit, Inverness County.*

Interval (Feet)	Insolubles	K_2O	Magnesium	Carnallite	Carnallite K_2O	Sylvite K_2O	Sylvite
996-997	0.76	14.11	0.002	0.02	0.003	14.11	22.29
1556-1567	10.37	13.37	0.017	0.19	0.030	13.34	21.08
1586-1586.5	36.43	0.28	0.041	0.47	0.077	0.20	0.32
1666.5-1667.5	22.02	0.11	0.024	0.27	0.044	0.07	0.11

*Data by Core Laboratories Limited (in Hale,1972).

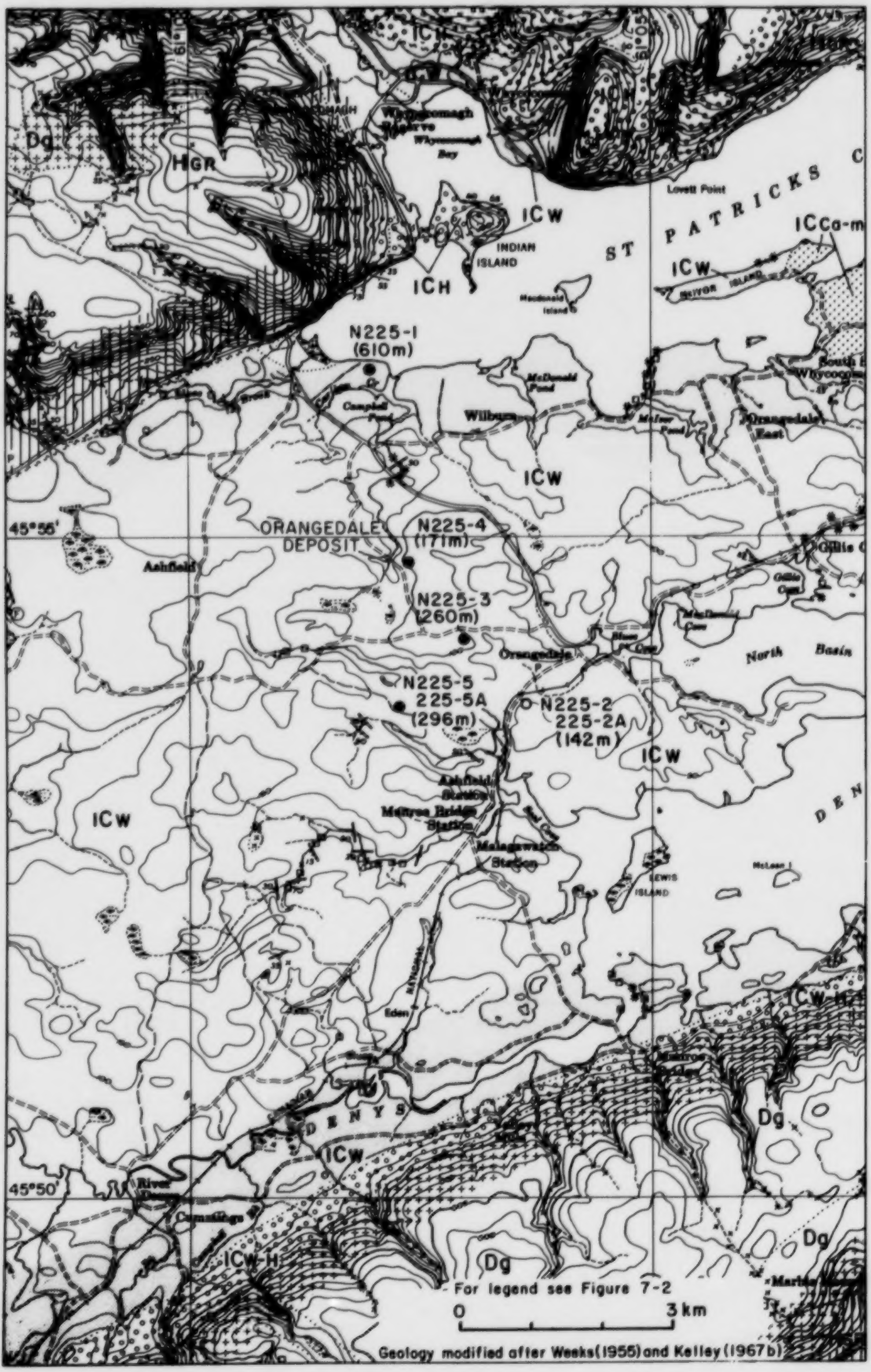

Dg
HGR
ICH
Whycocomagh Bay
Lovett Point
ICW
ST PATRICKS
ICCa-m
INDIAN ISLAND
ICH
ICW
McIVOR ISLAND
Macdonald Island
N225-1
(610m)
McDonald Pond
Wilburn
Campbell Pond
McIver Pond
Orangedale East
ICW
45°55'
ORANGEDALE DEPOSIT
N225-4
(171m)
Ashfield
Gillis Cove
N225-3
(260m)
North Basin
Orangedale
N225-5
225-5A
(296m)
N225-2
225-2A
(142m)
ICW
Ashfield Station
Melrose Bridge Station
Malagawatch Station
ICW
DEN
LEWIS ISLAND
McLean I
Eden
ICW-H
DENYS
Dg
ICW
45°50'
River Denys
Cummings
ICW-H
Dg
Dg
For legend see Figure 7-2
0
3 km
Geology modified after Weeks (1955) and Kelley (1967b)

Figure 7-12. Geology in the vicinity of the Malagawatch, Estmere and Orangedale deposits, Inverness County

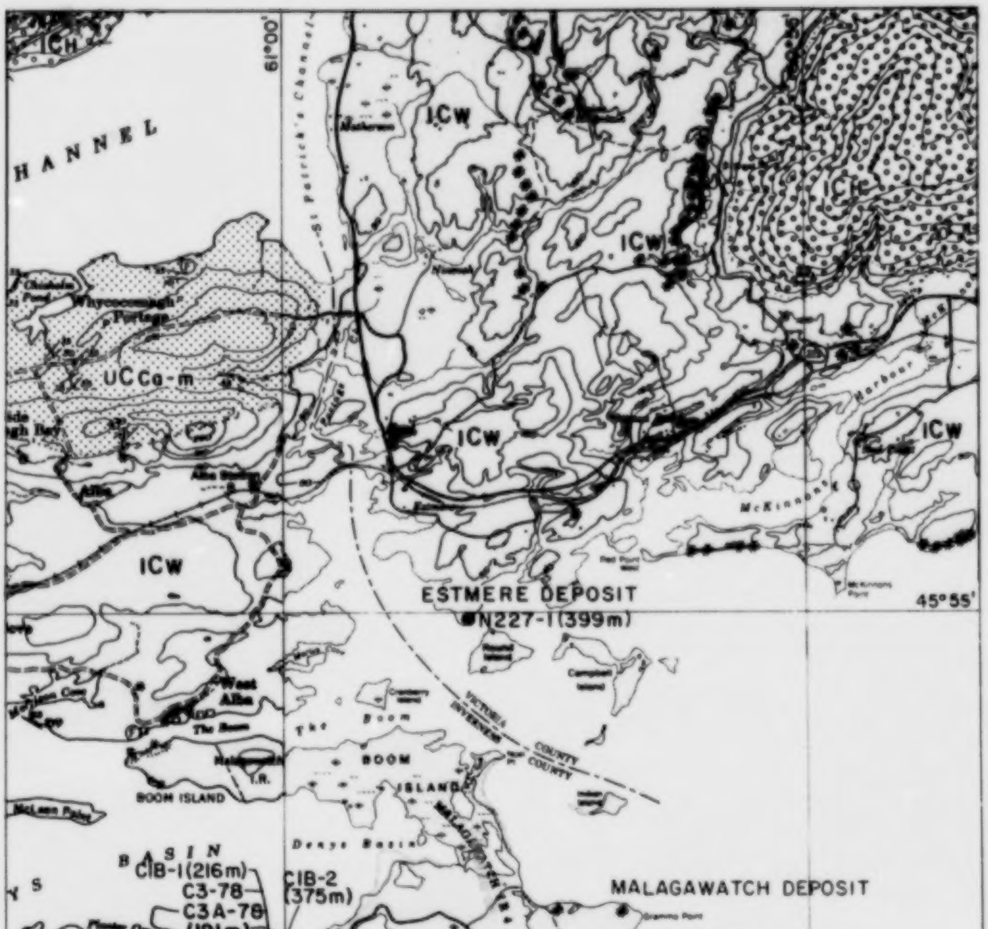
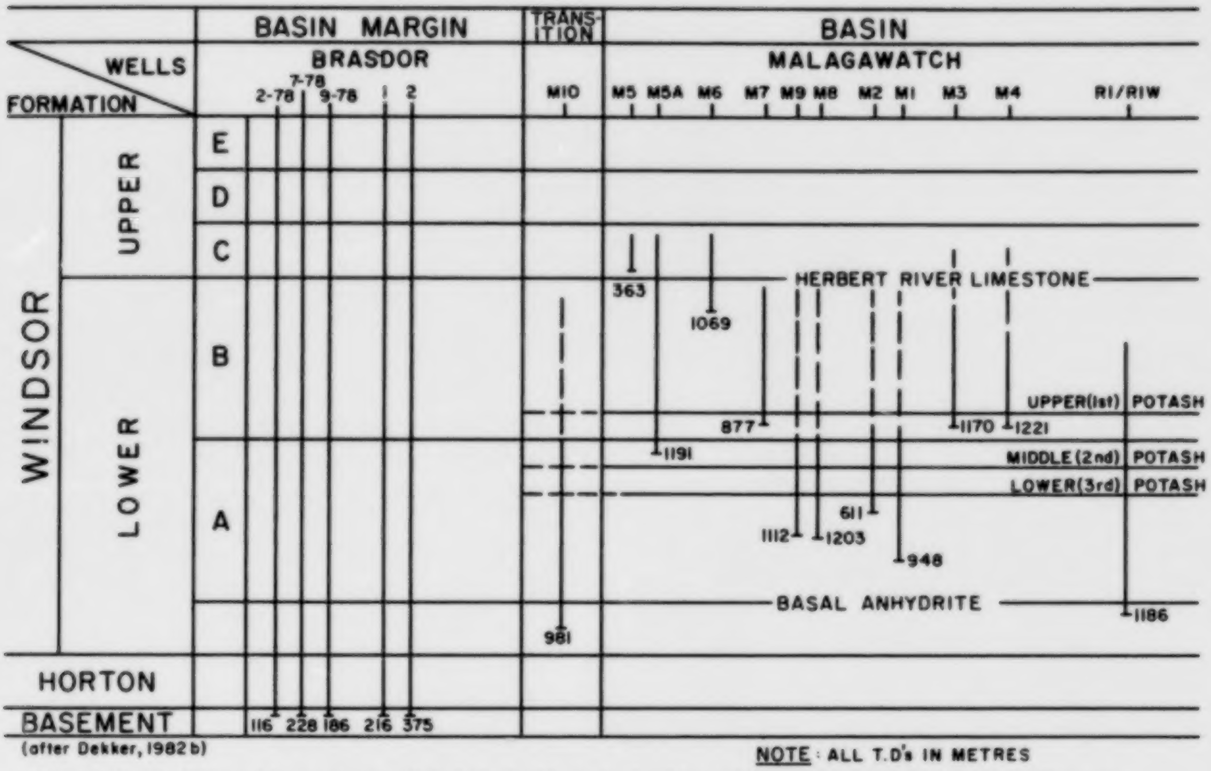

61°00'
ICH
HANNEL
St Patrick's Channel
ICW
Whycocomagh Portage
UCCa-m
ICW
ICW
ICH
ICW
ICW
ESTMERE DEPOSIT
N227-1(399m)
45°55'
West Alba
The Boom
BOOM ISLAND
BOOM ISLAND
VICTORIA COUNTY
INVERNESS COUNTY
BASIN
CIB-1(216m)
C3-78
C3A-78
(191m)
CIB-2
(375m)
Dg
CI-78(48m)
C7-78(228)
C2-78
(116m)
Dg
CM-10
(217m)
C9-78 (186m)
MALAGAWATCH DEPOSIT
CM-9 (181m)
BIG HARBOUR
ICW-m
CM-7
(290m)
CM-6
(312m)
ISLAND
CM-4
(350 m)
CM-3
(281m)
CIM-1(232m)
CIM-2(234m)
CM-8(250m)
CM-5a
(416m)
BRETON
ISLAND
Little Harbour
Dg
HGR
45°50'
McKenzie Cove
For legend see Figure 7-2
0
3km
Geology modified after Weeks (1955) and Kelley (1967b)

Figure 7-12. continued.



(after Dekker, 1982 b)

NOTE: ALL T.D's IN METRES

Figure 7-13. Schematic summary of total depth and stratigraphic section penetrated in Chevron Standard Ltd. drilling at Malagawatch and St. Patricks Channel.

by Ferguson (1946), Ferguson and Weeks (1950), Collins (1962) and Shea and Wallace (1962).

Outcrops of Windsor Group rocks are very rare and appear to be represented mainly by gypsum, shale and limestone. The geological maps covering the Port Richmond structure area portray it as a fault bound Windsor Group outcrop triangle bordered by Upper Carboniferous Riversdale Group. The majority of the structure appears to lie beneath the waters of Inhabitants Bay and Inhabitants Harbour (Fig. 7-6). The western border of the structure is defined by a north-northeasterly trending fault extending from Carleton Head towards Chappel Road. Here it is offset by an east-southeasterly trending fault that extends from the southern border of the McIntyre Lake structure into Inhabitants Harbour. This fault forms the northern border of the structure. The western border fault may extend from Carleton Head across Sea Coal Bay to the Strait of Canso (Shea and Wallace, 1962). The shallow drilling (DCPR-4 to -10) confirms the fault location (Figs. 7-6 and 7-15) along the western border. The southeastern border of the structure is also defined by faulting. The precise location of this boundary varies depending on which geological map you refer to (Shea and Wallace, 1962 and Collins, 1962). The fault or faults trend generally northeasterly and may be inferred to extend across Inhabitants Bay and connect with the western border fault.

In March 1967, Dow Chemical of Canada Limited drilled Port Richmond No. 1 (DCPR-1) (Fig. 7-10) on the point on the northern side of Murray Cove (Figs. 7-6 and 7-16). This hole was drilled to a total depth of 763 m (2503.5 ft.), intersected salt first at 508 m (1667 ft.) and did not completely penetrate the salt at final total depth (Rowe, 1967). In late 1967 Dow drilled a second hole, Port Richmond No. 2 (DCPR-2) near Carleton Head, south of Port Richmond (Rowe, 1968a). Salt was intersected in this hole at 549-643 m (1802-2110 ft.). Steep dips of 45°-75° were reported and several sections of shale and shale-salt breccia were reported (Fig. 7-16). From 643 m (2110 ft.) to the total depth at 732 m (2401 ft.) black shale, quartzite and conglomerate were tentatively identified as Horton Group although assignment to the Canso-Riversdale Group should not be ruled out. Traces of carnallite were reported in this well from 608-632 m (1994-2072 ft.).

At about the same time as Dow Chemical of Canada Limited was drilling DCPR-2, Dew Mining Corporation Limited was drilling CIL-1 (NSDM 4508) near the point on the eastern side of Murray Cove (Figs. 7-6 and 7-16). Salt was first intersected at 249.6 m (818.8 ft.) and was not completely penetrated at the final total depth at 679.8 m (2230.3 ft.). Scattered bands of anhydrite, shale and thin limestone are reported in the salt section. This type of section was

Table 7-4. Summary of assay results, Chevron Standard Ltd. drilling at Malagawatch and St. Patricks Channel (all intersections in all holes)**

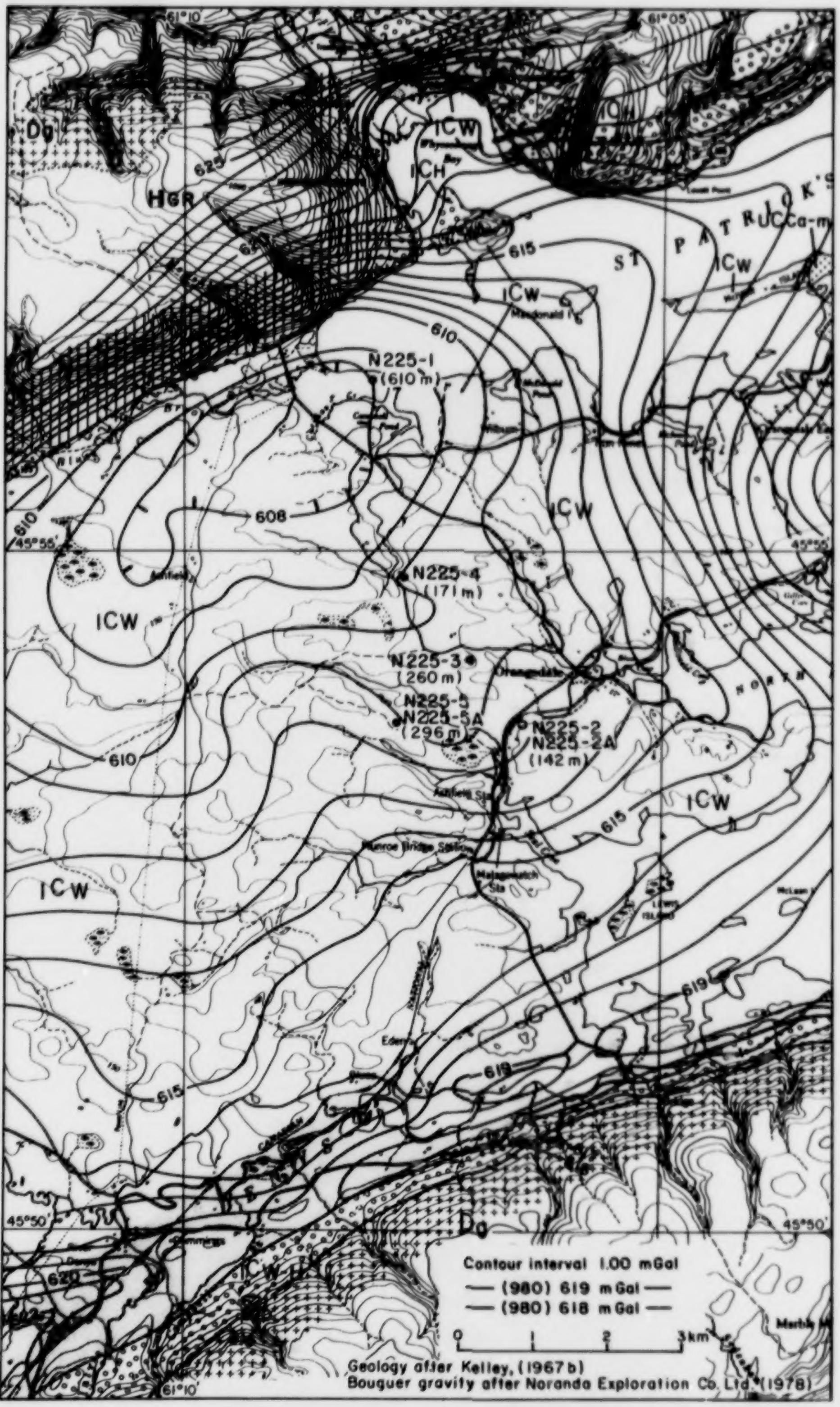
Hole No.	Upper	Middle	Lower	Interval (m)	Length (m)	Dip	True Width (m)	%K_2O	%Insols
M-1		+		*342 - 351	9	45°?	6.3	2.0	?
				*486 - 533	47	70°	15.8	>25	?
				*543 - 560	17	70°	5.7	>25	?
			+	560 - 571	11	70°	3.7	28.3	8
M-2		+		337 - 348	11	45°	7.7	2.3	2
			+	459 - 545	85	45°/70°	±40	10.3	2.1
M-3	+			946 - 950	4	45°	2.8	3.9	1.8
M-4	+			868.6 - 875.9	7.3	45°	5.1	1.8	2.9
M-5A	+			936 - 941.3	5.3	45°	3.7	3.6	3.9
M-6									
M-7	+			306.5 - 312.6	6.1	30°	5.3	14.8	5.4
M-8			+	331.4 - 351.6	20.2	70°	6.8	6.1	2.3
			+	492.9 - 500.7	7.8	70°	2.6	11.6	1.2
			+	688.2 - 700.4	12.2	70°	4.1	10	1.9
			+	969.2 - 978.2	9	45°	6.3	18.4	2.6
M-9			+	336.6 - 339.6	3	45°	2.1	16.2	1.4
			+	764.4 - 766.6	2.2	30°	1.9	27.1	5.1
			+	911.0 - 921.6	10.6	30°	9.1	13.4	2.8
M-10	+			290.9 - 300.2	9.3	45°	6.5	2.5	1.4
	+			430.9 - 433.3	2.4	30°	2.1	3.0	1.8
	+			444.8 - 446	1.2	30°	1.0	8.6	5.9
R-1		+		474.9 - 481.0	6.1	40°	4.2	<1	?
		+		502.2 - 508.3	6.1	40°	4.2	<1	?

All intervals in metres 0.63% K_2O cutoff (1% KCl) *Gamma Ray Log Calculated Assay Result

**after Dekker, (Table IX, 1982b)

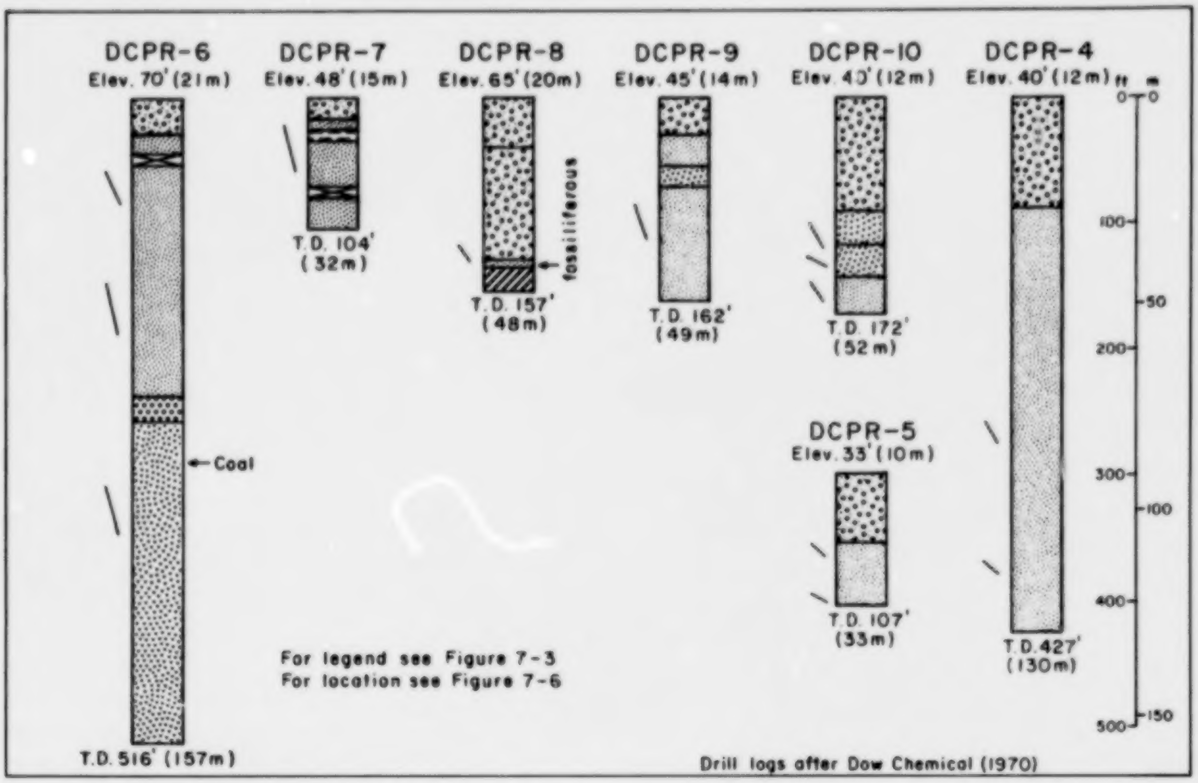
also described in Canso Strat No. 2 at McIntyre Lake (Hale, 1974). In early 1968 Dow Chemical Company drilled PR-3 (DCPR-3, Rowe, 1968b) on the point east of Port Richmond (Figs. 7-6 and 7-16). Salt was first intersected at 528 m (1732 ft.) and the hole was stopped in salt veined siltstone at 1576 m (5172 ft.). Numerous sections of siltstone, shale and salt-shale breccia were intersected in the salt interval. Bedding-banding dips throughout the salt section were reported to be steep (45° to 80°). Traces of carnallite were reported with a breccia interval at approximately 760 m (2500 ft.). Much of the salt was reported to be orange in colour. The section was interpreted to represent, for the most part, a fault zone. Palynology samples of some of the shale sections may be useful in determining the age of the nonevaporitic rocks in the section. It is not clear from the available data whether the shales are part of the Windsor, Canso-Riversdale or Horton Groups.

In late 1970 Dow Chemical Company Limited continued exploration by drilling a series of 7 shallow holes, DCPR-4 to DCPR-10 (less than 200 m) in the area west and north of Port Richmond (Figs. 7-6 and 7-15). DCPR-8, -7 and -6 were drilled in a northwestern trending line away from PR-2. DCPR-5 and -9, and DCPR-4 were similarly drilled northwest of PR-1. With the exception of veins and a thin section in DCPR-8, no evaporites were intersected in the holes. These holes


61°10'
61°05'
Dg
HGR
625
ICW
Whycocomagh Bay
ICH
ST PATRICK'S
UCca-m
615
610
N225-1
(610 m)
608
45°55'
ICW
N225-4
(171 m)
N225-3
(260 m)
N225-5
N225-5A
(296 m)
N225-2
N225-2A
(142 m)
Orangedale
615
ICW
610
619
615
620
45°50'
Dg
ICW
61°10'
Contour interval 1.00 mGal
(980) 619 mGal
(980) 618 mGal
0
1
2
3km

Geology after Kelley, (1967b)
Bouguer gravity after Noranda Exploration Co. Ltd. (1978)

Figure 7-14. Bouguer gravity anomaly map, Orangedale deposit, Inverness County.



For legend see Figure 7-3
For location see Figure 7-6

Drill logs after Dow Chemical (1970)

Figure 7-15. Drillhole profiles DCPR-4 to -10, Port Richmond deposit, Richmond County.

intersected variably disturbed terrigenous rocks of the Canso and Riversdale Groups and possibly some of the Windsor Group. In 1972 Dow Chemical Limited completed its exploration drilling program with the drilling of Port Malcolm No. 1 approximately 1 km east of DCPR-1 (Figs. 7-6 and 7-12). Salt, mainly as thin intervals alternating with anhydrite, siltstone and limestone, was reported in significant layers from 282.4 m (926.5 ft.) to the bottom of the hole at 624 m (2047 ft.). Dips throughout the section were reported to be steep (45° to 75°).

In early 1973 Dow Chemical of Canada Limited drilled a brine well (DCPR-11P) at the site of Port Richmond No. 1 to produce an underground storage cavity. This well was drilled to a total depth of 1227 m (4025 ft.). Three zones were considered as favourable for brining: Zone 1, 578.2-673.3 m (1897-2209 ft.); Zone 2, 784.3-837 m (2573-2746 ft.); and Zone 3, 857.1-907.7 m (2812-2978 ft.). Zone 3 was selected for development as a storage cavity. From 1973 to 1976 brining was carried out in Zone 3 and to a limited extent in Zone 2. As conditions were found to be unfavourable for the required capacity at this site, a second well (DCPR-12P) was drilled in 1975 approximately 300 m (1000 ft.) west of DCPR-11P. The favourable salt zones in this well were Zone 1, 484.6-535.2 m (1590-1756 ft.); and Zone 2, 675.4-752.2 m (2216-2468 ft.). Brining of Zone 2 began in July 1975. Problems encountered were related to the complex geology and the resultant unpredictability of insoluble layers. Although DCPR-11P and -12P are only 300 m (1000 ft.) apart the suitable salt zones are at drastically different depths and appear to have no apparent correlation. The Port Richmond deposit may be structurally similar to the Pugwash deposit or the McIntyre Lake deposit. Faulting and diapirism are considered responsible for the complex internal structure in this deposit (Fig. 7-17). Younger Windsor Group rocks, comprising variably disturbed interstratified anhydrite, limestone and shale with some halite occur as thick sections in NSDM 4508 and Port Malcolm No. 1 (PM-1) and as thinner disturbed sections in DCPR-1, -2, and -3. Due to a lack of data, a detailed assessment of the internal structure of the Port Richmond deposit is not possible at this time.

GEOPHYSICS

Attention was first drawn to the possibility of significant salt structures in the Port Richmond area by the presence of a high amplitude (30 mGal) Bouguer gravity low outlined by the Nova Scotia Research Foundation. Further surveys and model interpretations were carried out in the area by the Nova Scotia Research Foundation (1965a and b, 1966b, 1967c, 1971 and 1972) for Dow Chemical Company Limited and also for Dow

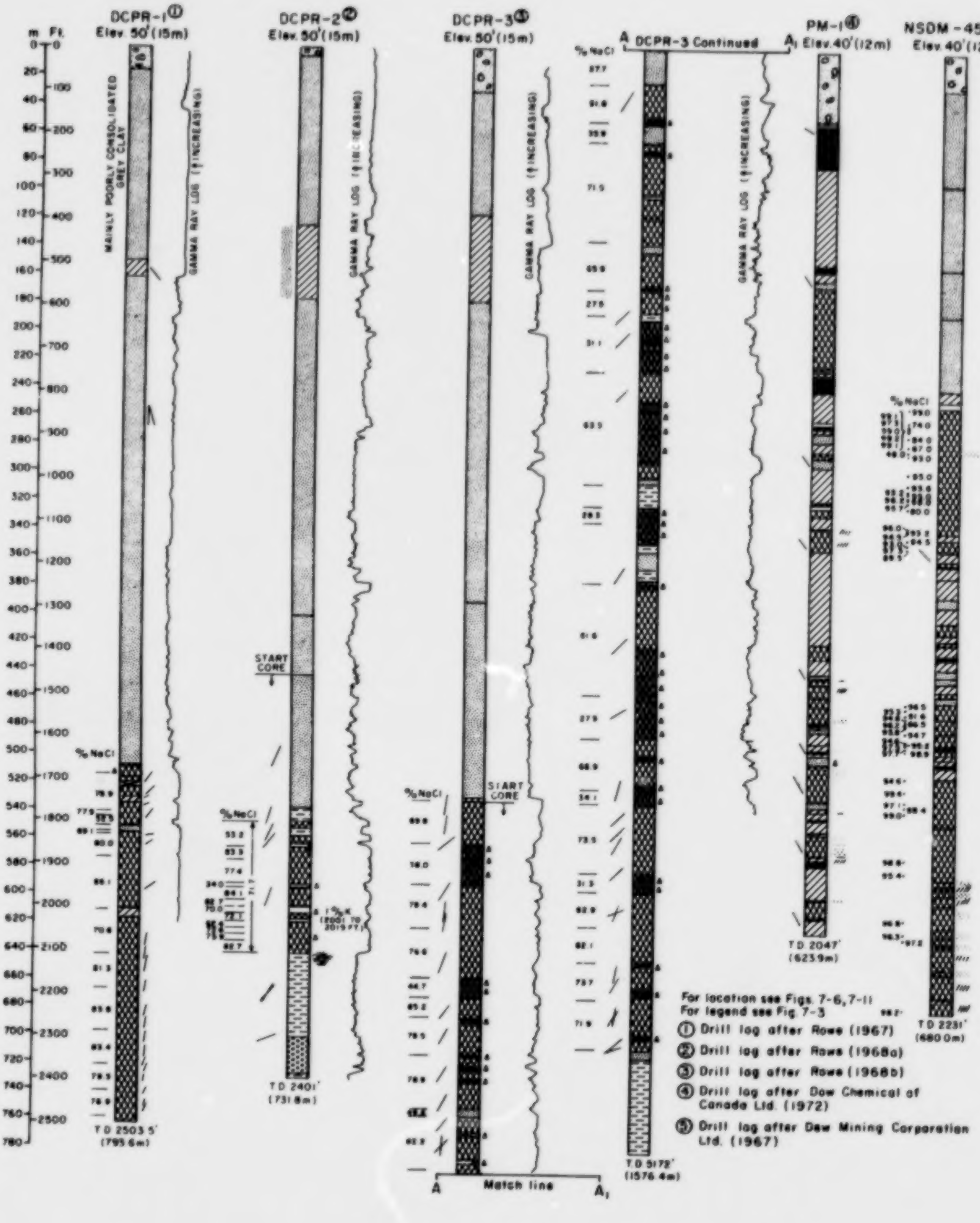
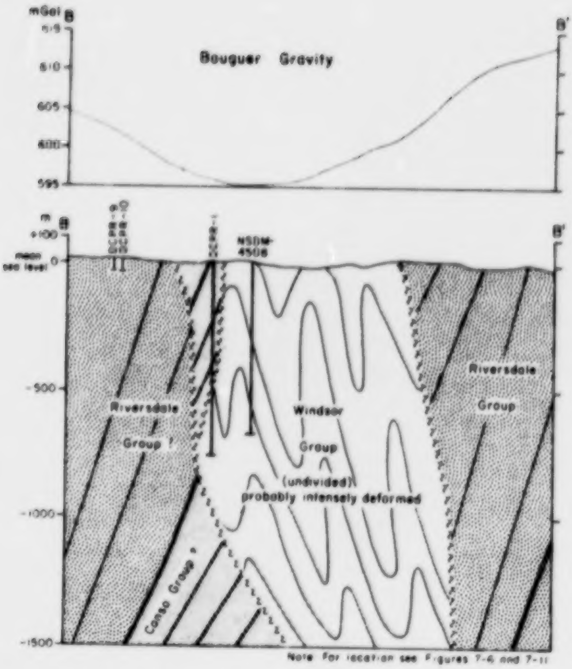

m Ft.
DCPR-1①
Elev. 50'(15m)
MAINLY POORLY CONSOLIDATED GREY CLAY
GAMMA RAY LOG (↑INCREASING)
% NaCl
T.D. 2503.5'
(795.6m)
DCPR-2②
Elev. 50'(15m)
GAMMA RAY LOG (↑INCREASING)
START CORE
% NaCl
T.D. 2401'
(731.8m)
DCPR-3③
Elev. 50'(15m)
GAMMA RAY LOG (↑INCREASING)
START CORE
% NaCl
A
Match line
A₁
A DCPR-3 Continued A₁
% NaCl
GAMMA RAY LOG (↑INCREASING)
T.D. 5172'
(1576.4m)
PM-1④
Elev. 40'(12m)
T.D. 2047'
(623.9m)
NSDM-4508⑤
Elev. 40'(12m)
% NaCl
T.D. 2231'
(680.0m)
For location see Figs. 7-6, 7-11
For legend see Fig. 7-3
① Drill log after Rowe (1967)
② Drill log after Rowe (1968a)
③ Drill log after Rowe (1968b)
④ Drill log after Dow Chemical of Canada Ltd. (1972)
⑤ Drill log after Dow Mining Corporation Ltd. (1967)

Figure 7-16. Drillhole profiles DCPR-1 to -3, PM-1 and CIL-1, Port Richmond deposit.



Note For location see Figures 7-6 and 7-11

Figure 7-17. Geological and Bouguer gravity cross-section, Port Richmond deposit, Richmond County.

Mining and Explorations. Details regarding these surveys and model interpretations are contained in the following unpublished maps and reports filed in the Nova Scotia Department of Mines and Energy, Halifax: Nova Scotia Research Foundation, 1965a (Report 20-65), 1965b (Report 20A-65), 1966b (Project C-5; Report 8-67), 1967c (Report 1-67), and 1972 (Report 2-72). The most recent map available is presented in Figure 7-11.

In addition to the gravity surveys, the Nova Scotia Research Foundation (1968d) was engaged by Dow Chemical of Canada Limited to do a Hydrosonde seismic survey in the Bay of Inhabitants. Approximately 14 track miles were surveyed and despite the limitation of penetration by shallow water, a number of shallow structural features were recognized.

As part of the diamond-drill exploration programs by Dow Chemical Company Limited downhole gamma ray logs were run by the Nova Scotia Research Foundation (Fig. 7-16) on Port Richmond Nos. 1, 2 and 3 (Rowe 1967, 1968a and b). More detailed downhole logs, including Compensated Sonic Log with gamma ray and caliper logs, and Compensated Formation Density Log with gamma ray and caliper logs, were run on DCPR-11P. At various stages during cavern development, sonar surveys were run to record the solution rate and the geometry of the cavern.

GEOCHEMISTRY

The exploration work by Dow Chemical of Canada Limited and to a lesser extent Dew Mining and Exploration has produced a relatively large volume of analytical data. These data are summarized on Figure 7-16, and in Tables 7-5, 7-6, 7-7, 7-8, 7-9 and 7-10 in Appendix 2.

ECONOMIC CONSIDERATIONS

The Port Richmond deposit is presently defined in five deep exploratory holes drilled on a high amplitude (30 mGal) Bouguer gravity anomaly. Significant sections of salt (exceeding 1000 m) were intersected although the continuity and correlation of the intervals was difficult to interpret due to the complex structure. Anhydrite, siltstone, shale breccia and limestone are interlayered with the salt in some sections. Potash salts (carnallite) were reported locally in trace quantities. The depth to the top of the salt section is variable, but it generally occurs at approximately 500 to 550 m below the surface.

Brine springs and seeps indicative of subsurface solution, have not been reported in this area. Possible development of the Port Richmond deposit may be hindered because the major portion of the salt structure occurs beneath Inhabitants Bay.

Dow Chemical Company Limited proceeded with the development of brined caverns for possible underground storage in the DCPR-11P and DCPR-12P wells until 1976 when the project was placed in a state of deferment. The Port Richmond deposit is advantageously situated in close proximity to ice free deep water port facilities and a heavy industrial area, including an oil refinery, along the Strait of Canso approximately 8 km west.

ST. PETERS DEPOSIT

The St. Peters deposit is situated near Tillard Point approximately 1 km west of the Town of St. Peters, Richmond County (NTS 11F/10) (Figs.1-10 and 7-18). St. Peters is located on southern Cape Breton Island approximately 40 km east of Port Hawkesbury on the Strait of Canso.

The area is readily accessible by an all weather highway, Route 4, between Port Hawkesbury and Sydney. A branch line of the Canadian National Railway to St. Peters, parallels Route 4, and passes within 300 m of the discovery drillhole, St. Peters No. 1.

The terrain in the area is typical of the Carboniferous Lowlands in southern Cape Breton where the gently rolling hills rarely exceed 75 m. Local relief is present, however, in the vicinity of gabbroic rocks forming a series of small hills along the southeastern side of St. Peters Inlet. The area to the northeast of the Lowlands is marked by flat topped highland area named Sporting Mountain, where elevations rise upward to 180 m.

HISTORICAL BACKGROUND

In 1967 the St. Peters area was selected by Domtar Limited as a potential area for salt

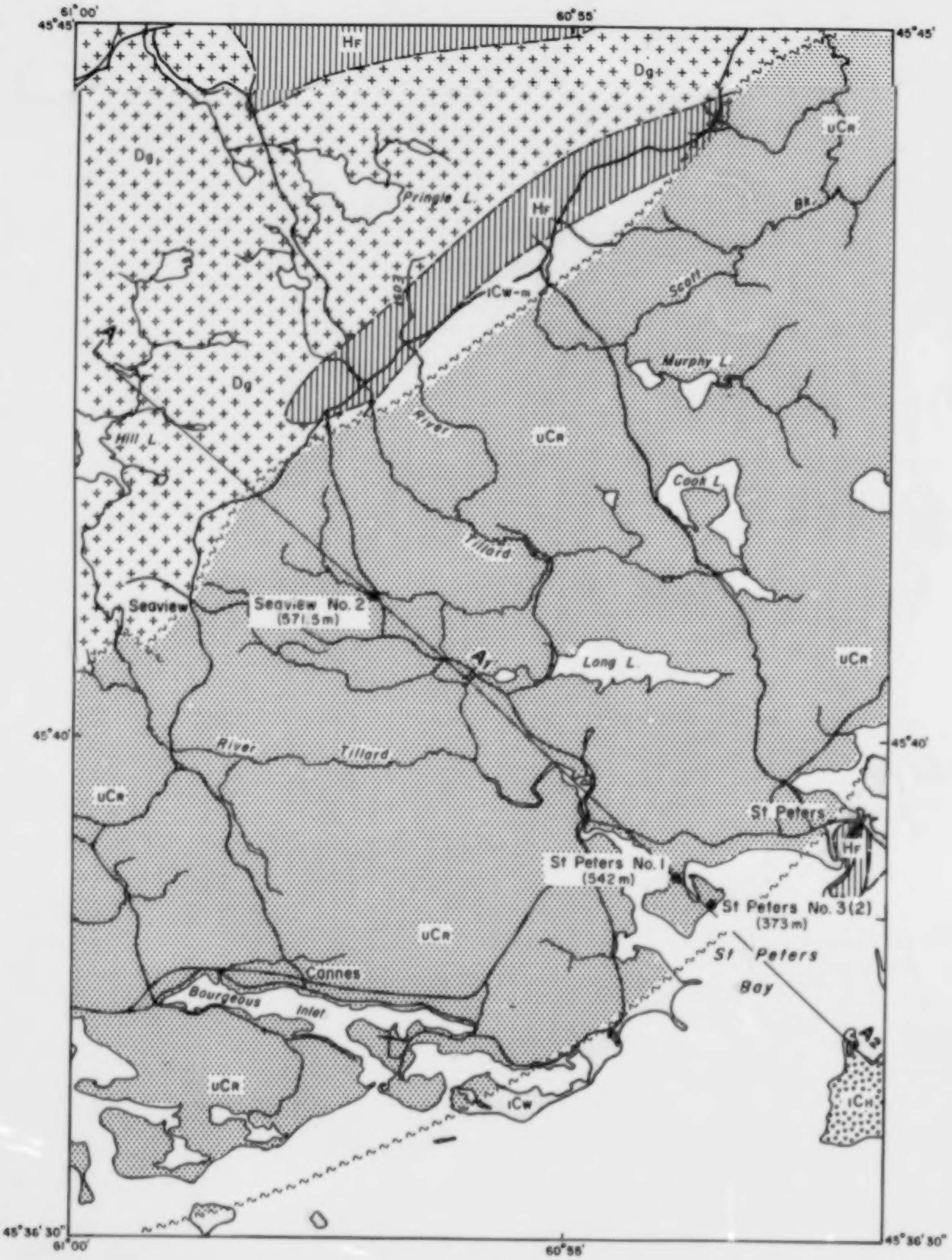
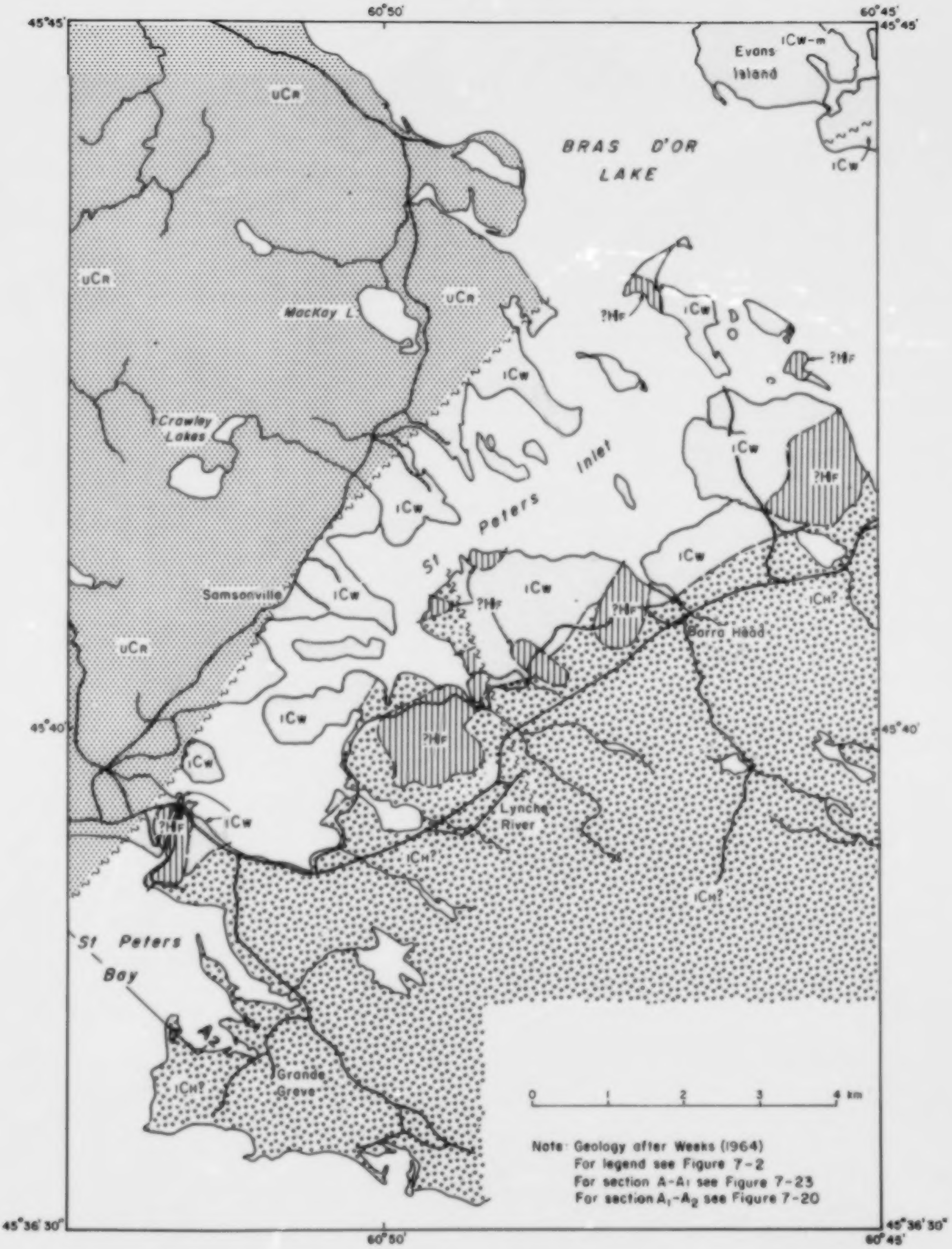

61°00'
60°55'
45°45'
45°45'
HF
Dg
Dg
Pringle L.
Hr
Hr
Dg
lCw-m
Scott
Br.
uCr
Murphy L.
Dg
Hill L.
River
uCr
Cook L.
Tillard
Seaview
Seaview No. 2
(571.5 m)
A1
Long L.
uCr
45°40'
45°40'
River
Tillard
uCr
St Peters
Hr
St Peters No. 1
(542 m)
St Peters No. 3(2)
(373 m)
uCr
St Peters
Bay
Cannes
Bourgeous
Inlet
A2
uCr
lCw
lCw
45°36'30"
61°00'
60°55'
45°36'30"

Figure 7-18. Geology in the vicinity of the St. Peters deposit and Seaview occurrence, Richmond County.

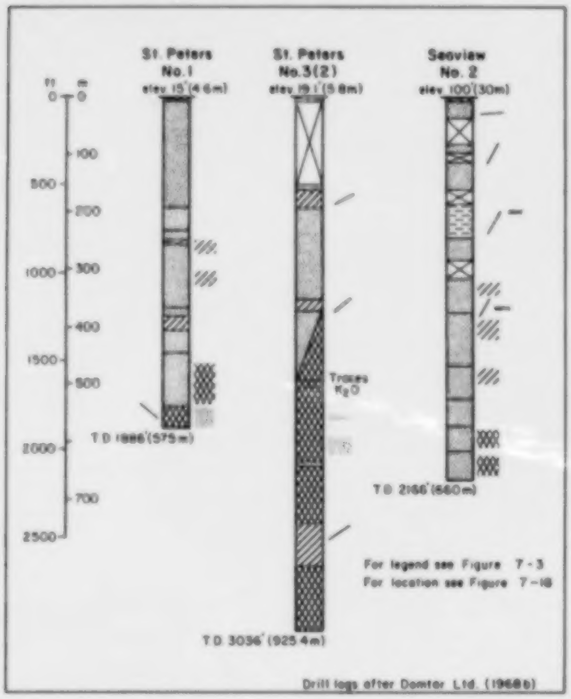

45°45'
60°50'
60°45'
45°45'
Evans Island
lCw-m
BRAS D'OR LAKE
lCw
uCr
uCr
MacKay L.
uCr
?Hf
lCw
?Hf
lCw
Crawley Lakes
lCw
St Peters Inlet
?Hf
lCw
lCw
Samsonville
lCw
?Hf
lCw
?Hf
Barra Head
lCh?
uCr
45°40'
lCw
?Hf
45°40'
lCw
?Hf
Lynche River
lCh?
lCh?
St Peters Bay
A2
Grande Greve
lCh?
0 1 2 3 4 km
45°36'30"
60°50'
45°36'30"
60°45'

Note: Geology after Weeks (1964)
For legend see Figure 7-2
For section A-A1 see Figure 7-23
For section A_1-A_2 see Figure 7-20

Figure 7-18. Continued.

exploration based on gravity surveys conducted for the company by the Nova Scotia Research Foundation (1967d).

Two exploration drillholes (Domtar, 1968b), St. Peters No. 1 and No. 2, were drilled in 1968 on a negative Bouguer gravity anomaly centred in St. Peters Bay (Figs. 7-1 and 7-19).



For legend see Figure 7-3
For location see Figure 7-18

Drill logs after Domtar Ltd. (1968b)

Figure 7-19. Drillhole profiles, St. Peters Nos. 1 and 3 (2) and Seaview No. 2, St. Peters deposit and Seaview occurrence, Richmond County.

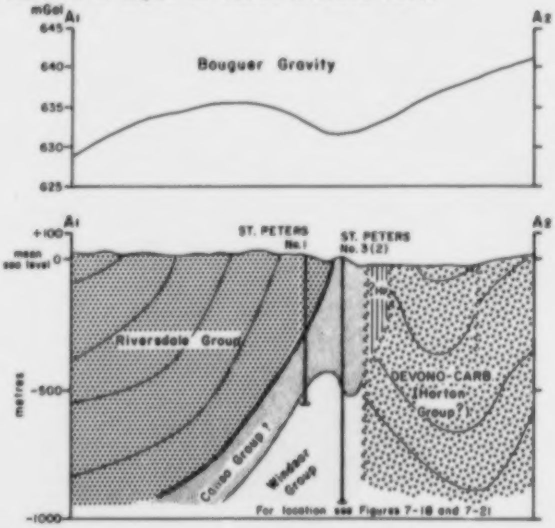
Although previous investigators did not realize salt was present in the St. Peters area Kindle (*in* Hayes, 1931) reported several salt seeps in the vicinity of a fault near Seaview, approximatley 7 km to the northwest.

GEOLOGY

The geology in the vicinity of the St. Peters deposit was described and mapped by Weeks (1954, Map 1026A) and Weeks (1964; Fig. 7-18).

The major part of the Carboniferous Lowlands in the area is underlain by Pennsylvanian Riversdale Group comprising sandstone, shale and conglomerate occurring in a syncline that extends into the Strait of Canso area. The Carboniferous rocks occur in a northeasterly trending graben defined by a pair of northeasterly trending faults. The fault to the north brings Riversdale Group in contact with the pre-Carboniferous basement rocks of Sporting Mountain. Onlap slivers of "marginal basin beds" and Grantmire Formation occur in several areas along this contact, including Seaview and Oban. The major fault to the south is indicated by Weeks (1954) to be part of the L'Ardoise thrust and to extend from River Bourgeois northeast to near Lake Uist (Figs. 7-18 and 1-10). This fault apparently brings Riversdale Group rocks in contact with Windsor Group "central basin beds". It appears to be reasonable to interpret the fault, in the vicinity of St. Peters, to be a high angle (normal or reverse) fault. Gabbroic rocks believed by Weeks (1954) to be possibly Mississippian age were described near the Windsor Group-Horton Group contact between St. Peters and Soldiers Cove. Keppie and Smith (1978) concluded that these rocks occur as fault slices, are at least pre-Horton age, and suggested petrographic and chemical similarities to Fourchu Group volcanics (Precambrian).

The Horton Group to the southeast occurs in a triangular outcrop area described by Weeks (1954) as the L'Ardoise thrust block whose structural configuration with Horton Group thrust over Windsor Group was defined in an exposure near Mount Auburn (Grand Narrows, Map 1040A Weeks, 1955). Domtar Limited (1968b) drilled St. Peters No. 1 on the western flank of a northeastern trending Bouguer gravity low near St. Peters (Figs. 7-19, 7-20 and 7-21). The hole was collared in rocks assigned by Weeks (1954) to the Riversdale Group which were intersected to approximately 244 m (800 ft.). Windsor Group shale and gypsum were intersected to approximately 448 m (1470 ft.) then siltstone with salt veins to approximately 549 m (1800 ft.) and pink halite with variably abundant shale to the final total depth at 575 m (1886 ft.). Dips throughout the hole are reported to be moderate to steep at 40°-60°. St. Peters No. 3 intersected a similar section and was abandoned in salt at a depth of 925.4 m (3036 ft.).



For location see Figures 7-18 and 7-21

Figure 7-20. Geological and Bouguer gravity cross-section, St. Peters deposit.

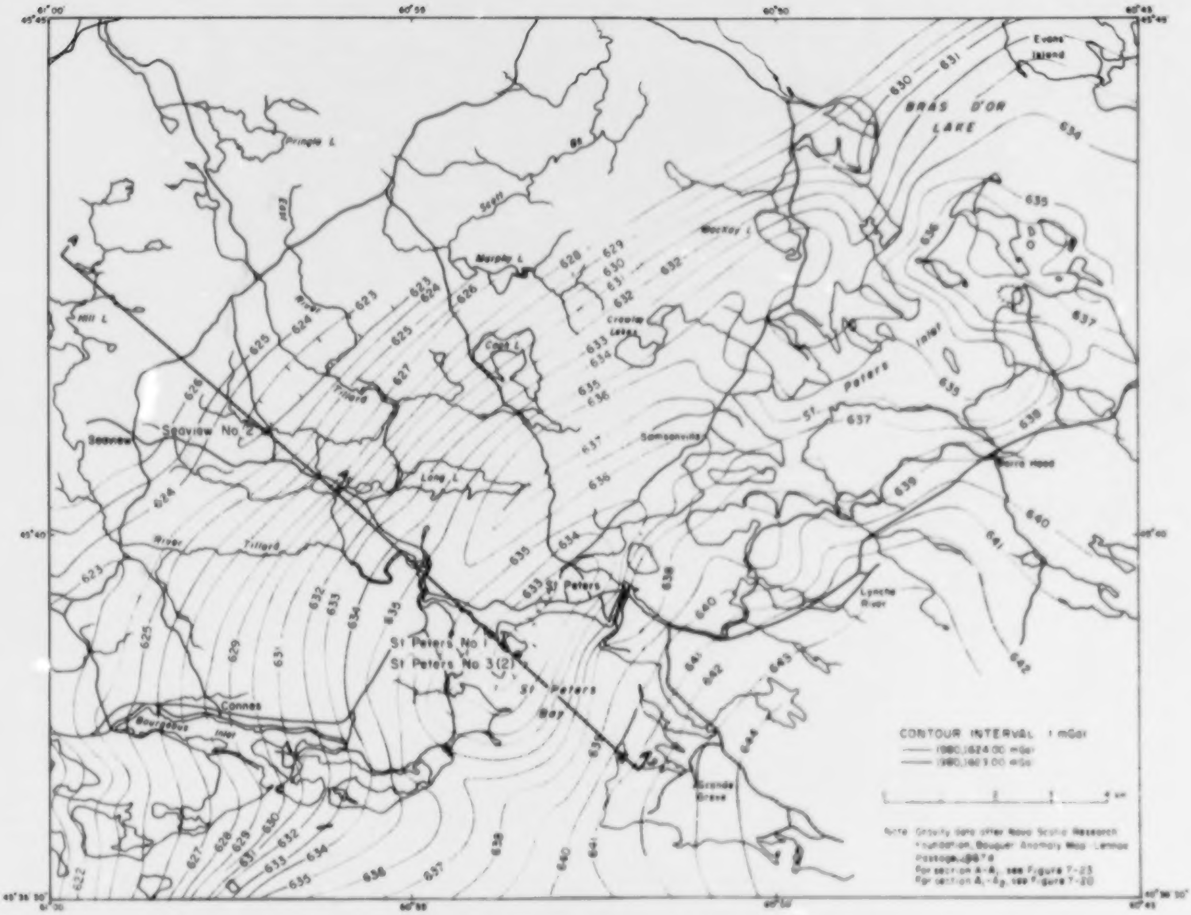

Evans Island
BRAS D'OR LAKE
Pringle L
Scott Br
Murphy L
MacKay L
Mill L
Crooks Lakes
St Peters Inlet
Seaview
Seaview No 2
Long L
River Tillard
Samsonville
St Peters
St Peters No 1
St Peters No 3(2)
St Peters Bay
Lynchs River
Grande Greve
Cannes
Bourgeois Inlet
CONTOUR INTERVAL 1 mGal
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644

Figure 7-21. Bouguer anomaly map, St. Peters-Seaview area, Richmond County.

St. Peters No. 1 and No. 2 are the only exploratory drillholes drilled to date on the St. Peters gravity anomaly. The location of the St. Peters Fault is inferred to lie to the south of St. Peters No. 3, but has not been accurately defined. Sites for potential exploration drillholes occur in the area of the core of the anomaly near the southern and eastern points of the Tillard Point penninsula and also in the vicinity of St. Peters and Jacksonville. The salt mass, presumed to be causing the gravity low, is inferred to be a fault related intrusion whose depth and configuration have yet to be established.

GEOPHYSICS

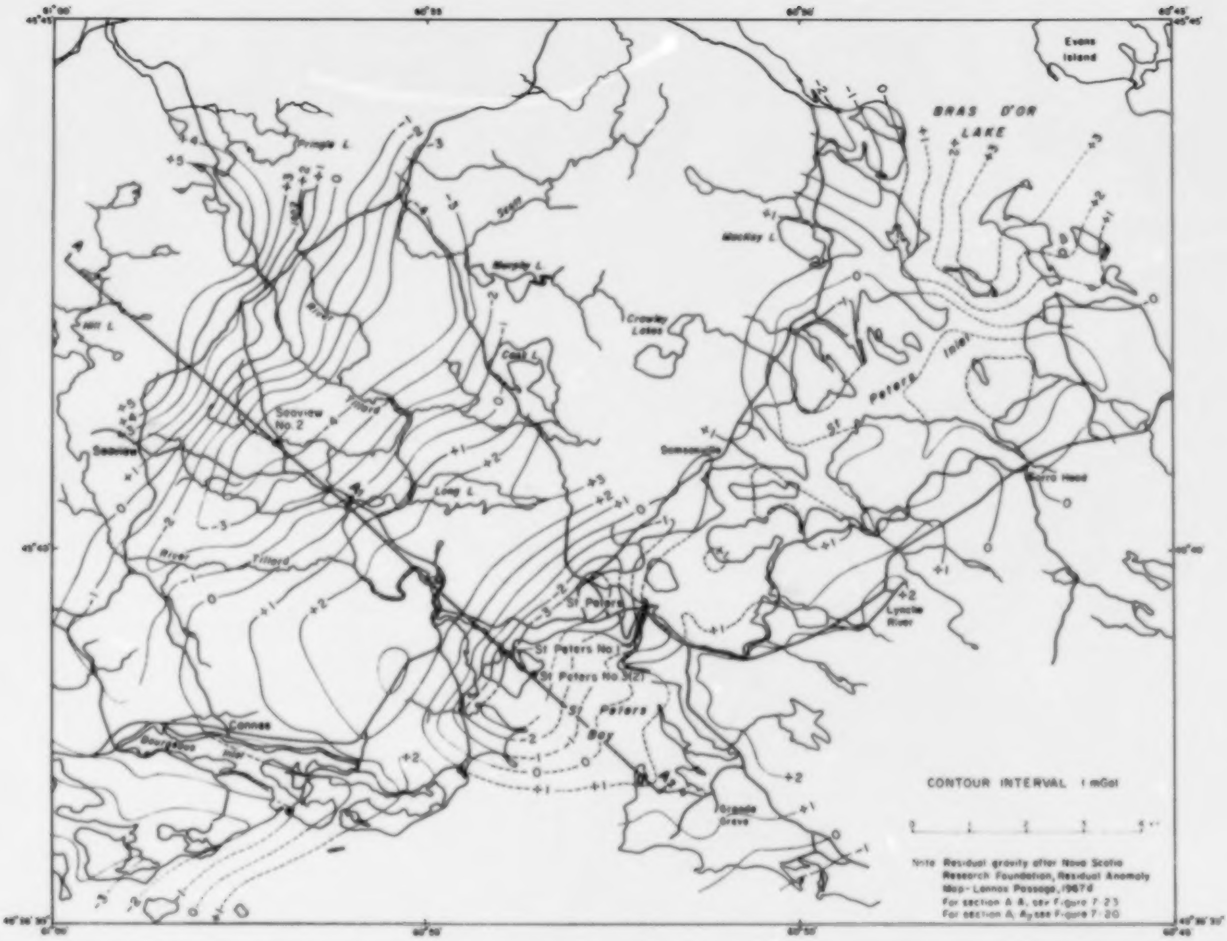
The area in the vicinity of the St. Peters deposit is included on Nova Scotia Research Foundation (1967d) Lennox Passage at a scale of 2 inches equals 1 mile (Fig. 7-21). In addition a Nova Scotia Research residual anomaly map, Lennox Passage, is available at a scale of 2 inches equal 1 mile (Fig. 7-22). The Bouguer gravity anomaly (12 mGal) is coincident with Windsor Group outcrop and has its long axis oriented northeast parallel to the major fault through St. Peters. In a larger view (Fig. 7-1) the Bouguer gravity low is a small depression in the major trough that extends into the Port Richmond low to the southwest.

ECONOMIC CONSIDERATIONS

The St. Peters deposit comprises variably pure, structurally disturbed halite associated with shale and siltstone breccia. Potash has not been reported in trace amounts at this location. A large part of the salt, as inferred from the Bouguer gravity anomaly, probably occurs beneath St. Peters Bay. Exploration to date on this structure has not been very encouraging. The deposit will require further exploration to determine its economic significance.

SEAVIEW OCCURRENCE

The Seaview occurrence is located approximately 2 km northeast of Seaview, Richmond County (11F/10) (Figs. 1-10 and 7-18). Seaview is situated


Evans Island
BRAS D'OR LAKE
Pringle L.
Mackay L.
Murphy L.
Crowley Lakes
Coal L.
Seaview No 2
Seaview
Tillard
River
Long L.
St Peters Inlet
Soldiers Cove
Barra Head
St Peters
St Peters No 1
St Peters No 3(2)
St Peters Bay
Lynche River
Cannes
Bourgeois Inlet
Grande Greve
CONTOUR INTERVAL 1 mGal
0 1 2 3 4 km

Note: Residual gravity after Nova Scotia Research Foundation, Residual Anomaly Map - Lennox Passage, 1967d
For section A-A, see Figure 7-23
For section A₁-A₁ see Figure 7-20

Figure 7-22. Residual gravity anomaly map, St. Peters-Seaview area, Richmond County.

approximately 8 km west-northwest of St. Peters and approximately 30 km northeast of Port Hawkesbury.

The Seaview area is accessible through a series of unpaved all weather roads connected with Route 4 which runs between Port Hawkesbury and Sydney. A Canadian National Railway branchline terminates at St. Peters and is located approximately 2 km south of Seaview.

The Seaview area is situated near the boundary of the Carboniferous Lowlands where elevations rarely exceed 75 m and the flat topped highlands of Sporting Mountain to the northwest where elevations rise rapidly to 180 m.

HISTORICAL BACKGROUND

The Seaview area was investigated for its salt and potash potential by Kindle as part of a regional survey under Hayes (1931). Several salt springs and seeps indicative of the dissolution of salt at depth were located and a geological map was prepared.

No further salt exploration activity was undertaken in the area until 1968 when Domtar Limited (1968b) drilled a Bouguer gravity low outlined by Nova Scotia Research Foundation (1967d).

GEOLOGY

The geology of the Seaview area is included in the published maps and reports by Weeks (1954 and 1964). Adjoining areas are covered by maps 11F/11W by Collins (1962) and Shea and Wallace (1962) and 11F/15 by Weeks (1955). The Seaview occurrence is situated on the northwestern side of a graben structure defined by Upper Carboniferous Canso-Riversdale Groups (Fig. 7-18). This structure is bounded by two faults trending northeast and is probably an extension of the synclinal structure described in the Canso Strait area. Mapping by Weeks (1954 and 1964) indicated the Windsor Group occurs in a series of slices of "marginal basin beds" or Grantmire Formation on the northwestern side of the Sporting Mountain Fault (Fig. 7-18). In these areas the Windsor Group apparently has onlapped onto the pre-Carboniferous basement rocks of Sporting Mountain.

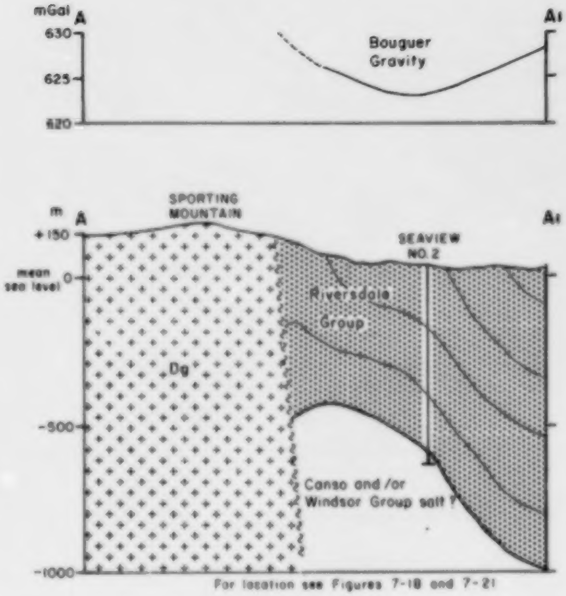
Kindle (in Hayes, 1931) reported that a three quarter mile long continuous section of Windsor Group occurs along the East Branch River Tillard situated approximately 2 km east of Seaview No. 1. Several outcrops of gypsum and laminated limestone were reported to be disturbed by a fault and associated locally with overturned beds. A salt spring was reported near the section and several salt springs were also reported adjacent to the Sporting Mountain Fault approximately 2 km north-northeast of Seaview No. 2. Subsequent mapping in the Seaview area by Weeks (1954 and 1964) did not recognize the Windsor Group indicated by Kindle (in Hayes, 1931) on East Branch River Tillard. Drilling by Domtar Limited (1968b) on a Bouguer gravity low indicated the Windsor Group occurs at a depth of approximately 380 m. Salt as veins and in shale-siltstone breccia was encountered from approximately 500 m to the bottom of the hole at 660 m (Fig. 7-19). The section in the upper part of the hole comprised shale and siltstone and may be part of the Canso Group. Although it is not unreasonable that Windsor Group occurs in the section described by Kindle (in Hayes, 1931b) along the East Branch River Tillard, it is also possible that the rocks may belong to the basal Canso Group. Thin gypsum and locally thin laminated limestone have been reported in some Canso Group sections such as Ragged Point (Norman, 1935). Saline facies including halite and anhydrite are recognized above the uppermost Windsor Group limestone in the Shubenacadie Basin (Giles and Boehner, 1979) and probably occur in the Port Richmond and McIntyre Lake deposits.

GEOPHYSICS

The area in the vicinity of Seaview is included on Nova Scotia Research Foundation (1967d) Bouguer anomaly map, Lennox Passage at a scale of 2 inches equals 1 mile (Fig. 7-21). A Nova Scotia Research Foundation (1967d) residual anomaly map, Lennox Passage covers a similar area at the same scale (Fig. 7-22). The Seaview occurrence is situated near the southeastern end of a narrow northeastward trending gravity trough.

The salt mass presumed to have produced the gravity low has not yet been established by drilling. The Bouguer anomaly map (Fig. 7-21) indicates that a northeastward trending gravity anomaly separates the Seaview and St. Peters anomalies. The Sporting Mountain Fault is inferred to be a high angle longitudinal fault with significant strike and dip slip motion (Fig. 7-23). The residual Bouguer anomaly (Fig. 7-22) indicates the structure may continue several kilometres to the northeast.

Since salt springs and seeps were reported by Kindle (in Hayes, 1931) approximately 2 km north of Seaview No. 2, this area may warrant further investigation. A small deflection in the residual gravity contours, together with the proximity of Windsor Group outcrop may be favourable indications of the presence of salt.



For location see Figures 7-18 and 7-21

Figure 7-23. Geological and Bouguer gravity cross-section, Seaview occurrence.

ECONOMIC CONSIDERATIONS

The Seaview occurrence consists of halite in veins and in association with shale-siltstone breccia. Salt springs, possibly related to the bounding fault, are reported approximately 2 km north of Seaview No. 2. A narrow Bouguer and residual gravity low outlined in the Seaview-Oban area may be caused by Windsor Group adjacent to the fault. Although salt encountered in Seaview No. 2 is not of economic importance, further exploration may establish a significant salt deposit.

RECENTLY DISCOVERED SALT DEPOSITS AND AREAS WITH SALT INDICATIONS IN THE CANSO-BRAS D'OR AREA

The preceding section has dealt with the known (i.e. drilled) salt deposits and occurrences in the Canso-Bras d'Or area. Exploration for salt in the area has occurred only in recent times and to date has been directed mainly at the major gravity anomalies and particularly those that are near the Strait of Canso. Salt springs and seeps indicative of the subsurface dissolution of salt are also relatively common away from the known salt areas. These salt springs and seeps located and described in reports by How (1869), Hayes (1931) and Cole (1930a) form the basis for the following summary. Several of these have been located on more recent maps by Kelley (1967a, b).

CLEVELAND DEPOSIT

The Cleveland deposit (Figs. 1-10 and 7-6) has been discovered recently in potash exploration drilling by Noranda Exploration Co. Ltd. (1981)

near Cleveland (Fig. 7-6). Salt was intersected in drillhole N227-2 at 732 m (2403 ft.) to the total depth at 1054 m (3457 ft.). Traces of potash salts were reported.

ESTMERE DEPOSIT

Exploration drilling by Noranda Exploration Co. Ltd. (1981) has recently established a new salt deposit near Estmere (Figs. 1-10 and 7-12). Salt bearing section was intersected in drillhole N227-1 from 399 m (1308 ft.) to the total depth at 860 m (2822 ft.).

ST. PATRICKS CHANNEL DEPOSIT

Salt has recently been discovered by Chevron Standard Ltd. (Dekker, 1982b) in drillhole R1/R1W at McIvor Pt. located 25 km northeast of the Orangedale deposit (Fig. 1-10). Salt bearing section was intersected at 396.5 to 1174 m (1301-3853 ft.)

ST. PATRICKS CHANNEL AREA, BRAS D'OR LAKES

The St. Patricks Channel area is situated approximately 15 km southwest of Baddeck, near Whycocomagh in the River Denys Valley, Victoria County, central Cape Breton (Figs. 1-10 and 7-1). The geology in the vicinity was described and mapped by Kelley (1967b) which includes the Whycocomagh and Baddeck map areas 11F/14 and 11K/03. Salt was confirmed in Orangedale deposit area by Noranda Exploration Co. Ltd. (1979).

Bucklaw

According to Cole(1930a) indications of salt in this area were first reported by Robb in 1873 who described the occurrence of a salt spring at Bucklaw, located 100 m south of Route 105 and just east of the Victoria and Inverness Counties line.

Cole (1930a) stated that Robb described the salt springs as follows:

> Appear to issue from rocks lying towards the base of the Lower Carboniferous formation, and are situated on the north side of the Little Narrows of Bras D'Or Lake, between the shore and the road, about 12 miles southwest of Baddeck, on land belonging to James Watson, miller. Here several saline springs of more or less strength occur in close proximity over an area of about 12 acres of flat marshy land. Much hydrated peroxide of iron is deposited in the water courses, the odour of sulphuretted hydrogen pervades the atmosphere in the vicinity, and the vegetation is destroyed around all the springs. The strongest spring from which about a gallon was taken for analysis, appeared to me to discharge from 100 to 200 gallons per minute. It was stated by evaporating in two common iron pots, each containing about three gallons, from which two to three bushels of salt were made per day. I was further informed that it had been proposed many years ago to establish works for the manufacture of salt at this place, and that machinery had actually been ordered for that purpose, but I am not aware for what reason the undertaking was abandoned.

The sample taken from this spring by Robb was analyzed by Hoffman and the following analyses in Table 7-11 were reported by Cole (1930a).

Table 7-11. Chemical analyses, Bucklaw spring, Victoria County*

Bucklaw Spring

The filtered brine contained in 1,000 parts:

Sodium	19.9423
Potassium	0.1019
Calcium	1.6709
Magnesium	0.0403
Iron	absent
Alumina	traces
Chlorine	30.9585
Sulphuric Acid (SO_4)	4.0162
Silica	traces
OR	
Chloride of sodium	50.6881
Chloride of potassium	0.1942
Chloride of magnesium	0.1593
Sulphate of calcium	5.6810
Alumina	traces
Silica	traces
	56.7226

*Hoffman in Cole (1930a)

Hayes (1931), reported that boring operations were begun at the Bucklaw site in the fall of 1921 by Ross for Prospectors Limited.

Hayes (1931) stated:

> At the time of the visit (1922) three bore holes, numbered 1, 2, and 3, had been drilled to depths of 170, 95, and 71 feet, respectively, and boring was still in progress at No. 3 bore hole. Nos. 2 and 3 holes gave flows of strong brines registering from 26 to 32 per cent saturation with the salometer. At No. 2 hole, 70 to 100 gallons per minute was flowing from a 3-inch pipe and overflowed 10 feet above the surface. The flow of saline water began at a depth of 46 feet in No. 2 hole, and 70 feet in No. 3 hole, after having passed through a layer 3 and 2 feet thick, of mottled red and white, very plastic clay, which evidently acts as an impervious cover preventing the escape of the saline water and entry of the surface water. Hence, the necessity of keeping this cover of clay undisturbed and well closed to conserve the quantity and quality of the brine available. Below the flow of brine to the bottom of the two bore holes the drill passed through soft clay-shale dipping vertically. Samples of the borings have been received from George J. Ross by the Borings Division. A sample of salt obtained by the writer from the evaporation of about one gallon of the brine has been submitted to the Mineralogical Division to be

assayed. It is reported that drilling operations are still in progress, and the company is considering the erection of a plant for the evaporation of the brine and the manufacture of salt of good quality.

The springs occur on a strip of flat land at the foot of Skye Mountain, between the sea shore and the post road, along a narrow zone for a distance of about 1500 feet in a northeasterly direction. Three kinds of springs were observed. Nearer to the shore are the saline springs; one to three hundred feet back are bitter, sulphurous and ferruginous water springs; and quite near these are a few cold, clear, pure water springs.

Much hydrated peroxide of iron is deposited in the water sources; the odour of sulphuretted hydrogen pervades the atmosphere in the vicinity, and the vegetation is destroyed around some of the springs. In the dry season, evaporation produces crystalline salt which looks like snowflakes on the black muck of the dried up saline ponds, and on the stones surrounding the springs.

In a small brook that crosses the springs area, friable red concretionary shale, grit and conglomerate of lower Carboniferous age outcrop just above the road and dip southeasterly at an angle of 80 degrees. A short distance up the brook these rocks are underlain by gray, sparkling, micaceous, compact and banded quartzites, which pass still farther up into granite and syenitic gneiss with specks of hornblende that form Skye Mountain and are Precambrian, according to Fletcher. Westward from the springs area, along the road that skirts the mountain, gypsum, limestone and conglomerate outcrop on the lowland, and micaceous quartzite on the mountain side. Saline and other mineral springs are said to occur at several places along the road to and beyond Whycocomagh.

In early 1925 the Nova Scotia Department of Mines (1926) drilled a diamond-drill hole (NSDM 478) for Prospectors Limited. This hole intersected red shales and gypsum and was abandoned at a depth of 470 feet.

Cole (1930a) sampled and analyzed water flowing from the drillhole in 1927 and 1928 and reported the results in Table 7-12. The spring has a low $CaSO_4$ content and is typical of the NaCl salt springs in Nova Scotia.

Little Narrows

Little Narrows is located near the southern end of St. Patricks Channel approximately 2 km south of Bucklaw and 8 km east-northeast of Whycocomagh (Figs. 1-10 and 7-1).

A large open-pit gypsum mine is operated at Little Narrows by the Little Narrows Gypsum Company. Salt in minor, erratically distributed impurity zones has been encountered in certain parts of the gypsum mine and its distribution and chemistry were studied and described by Holleman (1976) in an unpublished M.Sc. thesis at Acadia University.

Table 7-12. Chemical analyses, drillhole NSDM 478, Bucklaw, Victoria County.*

Sampled 1927

	% in Brine	Total solids calculated %
Potassium	trace	trace
Sodium	2.307	32.86
Calcium	0.366	5.21
Magnesium	0.009	0.13
Sulphuric Acid (SO_4)	0.440	6.26
Chlorine	3.900	55.54
Bromine	trace	trace
Iodine	none	none
Total	7.022	100.00

Total dissolved saline matter by direct experiment, dried at 110°C - 7.18%
Specific gravity at 15.5°C - 1.050

Sampled 1928

Sample No.		16
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere, °F		85
Temperature of brine, °F		56
Baume degrees		6.25
Equivalent specific gravity		1.043
LABORATORY NOTES		
Specific gravity at 60°F		1.049
Total solids at 110°C		5.83
Reaction		N
ANALYSES OF SOLIDS		
Na	Per cent	34.51
K	Per cent	0.07
Ca	Per cent	2.71
Mg	Per cent	0.11
SO_4	Per cent	6.10
Cl	Per cent	53.89
Br	Per cent	none
I	Per cent	none
Total		97.39
HYPOTHETICAL COMBINATION		
$CaSO_4$	Per cent	8.64
$CaCl_2$	Per cent	0.47
$MgSO_4$	Per cent	-
$MgCl_2$	Per cent	0.43
K_2SO_4	Per cent	-
KCl	Per cent	0.13
Na_2SO_4	Per cent	-
NaCl	Per cent	87.72
Total		97.39

*Cole (1930a)

Whycocomagh

Hayes (1931) also described salt springs in the vicinity of Whycocomagh as follows:

> A small stream which crosses the main road in Whycocomagh Village, Inverness County, is slightly saline but the actual spring feeding the creek was not located. About four miles

east of the village on the north shore of St. Patrick Channel, three springs flow out of the base of the escarpment beneath the Whycocomagh Baddeck highway. These springs have a combined flow of approximately 100 gallons per minute, but their salinity is low.

Cole (1930a) reported the analyses of salt brine sampled at the Whycocomagh spring in Table 7-13. This spring has a low $CaSO_4$ content but is anomalous in that high $CaCl_2$ is indicated in a normative calculation.

Table 7-13. Chemical analyses, Whycocomagh spring, Inverness County.*

Sample No.	7
FIELD NOTES AT TIME OF SAMPLING	
Temperature of atmosphere, °F	73
Temperature of brine, °F	43
Baume degrees	0.5
Equivalent specific gravity	1.003
LABORATORY NOTES	
Specific gravity at 60°F	81.001
Total solids at 110°C	0.33
Reaction	N
ANALYSES OF SOLIDS	
Na ... Per cent	36.92
K ... Per cent	0.08
Ca ... Per cent	2.00
Mg ... Per cent	0.26
SO_4 ... Per cent	0.90
Cl ... Per cent	59.05
Br ... Per cent	none
I ... Per cent	none
Total	99.21
HYPOTHETICAL COMBINATION	
$CaSO_4$ ... Per cent	1.28
$CaCl_2$ ... Per cent	4.49
$MgSO_4$ ... Per cent	-
$MgCl_2$ ... Per cent	1.02
K_2SO_4 ... Per cent	-
KCl ... Per cent	0.15
Na_2SO_4 ... Per cent	-
NaCl ... Per cent	92.27
Total	99.21

*Cole (1930a)

Kelley (1967b), who described and mapped the geology in this area, indicated the occurrence of a salt spring at Whycocomagh.

Baddeck

Salt springs are also described in the vicinity of Baddeck by Cole (1930a), as follows:

> There are two brine springs on the north side of the Baddeck-Ross Ferry highway about three miles east of Baddeck, Victoria County. The more easterly spring (No. 19) has a flow of about 1 gallon per minute. This spring occurs just off the north side of the road in a meadow swale and seeps up in a number of places. The shore of Baddeck bay for several acres in the vicinity is covered with the typical salt plant on the flat between the road and high tide level. The west spring (No. 20) has a flow estimated at 2 gallons per minute. This spring comes out of the side hill on the north side of the road 100 yards west of spring No. 19. It is situated 75 feet east of stand pipe and watering trough on the north side or road.

Hayes (1931) indicated that these might easily be mistaken for a portion of tidal water until carefully examined. Both springs were sampled and analyzed by Cole (1930a) (Table 7-14). The composition of these two springs is very similar with low $CaSO_4$ in a dominantly NaCl water.

Table 7-14. Chemical analyses, Baddeck springs, Victoria County.*

Sample No.	19	20
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere, °F	76	76
Temperature of brine, °F	60	51
Baume degrees	6.0	5.0
Equivalent specific gravity	1.041	1.034
LABORATORY NOTES		
Specific gravity at 60°F	1.0357	1.0177
Total solids at 110°C	5.00	2.36
Reaction	N	N
ANALYSES OF SOLIDS		
Na ... Per cent	36.45	35.12
K ... Per cent	0.21	0.21
Ca ... Per cent	1.11	1.06
Mg ... Per cent	0.17	0.18
SO_4 ... Per cent	1.65	11.48
Cl ... Per cent	57.65	55.98
Br ... Per cent	none	n.d.
I ... Per cent	none	n.d.
Totals	97.24	94.03
HYPOTHETICAL COMBINATION		
$CaSO_4$ ... Per cent	2.34	2.09
$CaCl_2$ ... Per cent	1.16	1.25
$MgSO_4$ ... Per cent	-	-
$MgCl_2$ ... Per cent	0.67	0.71
K_2SO_4 ... Per cent	-	-
KCl ... Per cent	0.40	0.40
Na_2SO_4 ... Per cent	-	-
NaCl ... Per cent	92.67	89.58
Totals	97.23	94.03

*Cole (1930a)

Orangedale

Cole (1930a) described salt springs in the Orangedale area located approximately 8 km south of Whycocomagh. He reported a salt spring located one mile west-southwest of Orangedale and 600 m (2000 ft.) south of the McAulay road. This spring was sampled and analyzed by Cole (1930a) (Table 7-15).

The composition of this spring is typical of low-moderate $CaSO_4$ bearing salt springs in Nova Scotia. The spring is anomalous in its $MgCl_2$ content.

Table 7-15. Chemical analyses, Orangedale Spring, Inverness County.*

Sample No.		**18**
FIELD NOTES AT TIME OF SAMPLING		
Temperature of atmosphere, °F		68
Temperature of brine, °F		47
Baume degrees		5.0
Equivalent specific gravity		1.034
LABORATORY NOTES		
Specific gravity at 60°F		1.0239
Total solids at 110°C		3.26
Reaction		N
ANALYSES OF SOLIDS		
Na	Per cent	31.91
K	Per cent	0.06
Ca	Per cent	4.16
Mg	Per cent	0.26
SO_4	Per cent	9.27
Cl	Per cent	50.54
Br	Per cent	none
I	Per cent	none
Totals		96.20
HYPOTHETICAL COMBINATION		
$CaSO_4$	Per cent	13.13
$CaCl_2$	Per cent	0.83
$MgSO_4$	Per cent	-
$MgCl_2$	Per cent	1.02
K_2SO_4	Per cent	-
KCl	Per cent	0.11
Na_2SO_4	Per cent	-
NaCl	Per cent	81.11
Totals		96.20

*Cole (1930a)

Dundee-Black River Area

Kindle (in Hayes, 1931) described the occurrence of salt springs in the Dundee area, Cape Breton. Dundee is located on the southern shore of West Bay, Richmond County, approximately 6 km east of West Bay which is located approximately 18 km northeast of Port Hawkesbury (Fig. 1-10). Kindle reported that Windsor Group rocks outcrop three miles up the Black River near Dundee.

The occurrence of salt springs is described by Kindle (in Hayes, 1931) as follows:

> Two miles upstream from tidewater alongside a tributary stream are five or more salt springs reading 3.6 Baume scale on J. Smith's and Nathan Hill's land, the strongest flowing 1 1/2 gallons per minute. Northward 300 feet are two large water-filled sinkholes, gypsum in the creek, and at 600 feet another strong salt spring. Still another small salt seep occurs 1 1/2 miles down the river (shown on the map). Analyses for potash have not yet been made. The structure of the enclosing beds at Smith's and Hill's springs is anticlinal, a limestone of the north limb of which is marked by Windsor Zone E fossils. Thick beds of gypsum riddled with red ochre are exposed downstream 3/4 mile, East side, at road ford at Murray's old house where they have been faulted up against Pennsylvanian sandstone.
>
> This exposure of Windsor is closely bounded and overlain by Pennsylvanian sandstones and conglomerates on the west. To the north, east, and southeast, pre-Carboniferous hills stand up high within half a mile of the springs. The Windsor series seems to have been faulted and turned on edge 1/4 mile to the southwest at the Falls on Black River, but westward for four miles the salt bed may remain covered with gently dipping Pennsylvanian sandstones. The anticline in the Windsor at the springs is outlined by the 20° easterly dip of Zone E limestone, associated with gypsum in the creek strikes the same direction in line with two sinkholes. Southward, approximately 660 feet, limestone and sandstone dip 35° S.E. and 100 feet farther south gypsum and limestone dip 42° in the same direction. These two strikes converge slightly eastward with the Zone E limestone nearly one-half mile N.

How (1869) reported the occurrence of several mineral springs in Cape Breton as follows:

> There are three springs mentioned as affording the water examined; they are situated near Kelly's, on the high road from Sydney to St. Peters, in a brook which empties into the Salmon River and is distant about two or three miles from the source of the river and six or seven from the southern shore of Bras d'Or Lake. The waters rise in syenitic rocks and the flow is not more than a gallon per minute.

The following analyses were calcuated for an Imperial gallon of 70 000 grains (How, 1969):

	grains per gallon*
Iron and phosphoric acid	traces
Carbonates of lime and magnesia	0.60
Sulphate of lime	0.94
Chloride of sodium	343.11
Chloride of potassium	4.55
Chloride of calcium	308.90
Chloride of magnesium	4.47
Total	662.57

sg at 54°F 1007.397

*1 grain/imp. gal. = 0.01425 gm/l

Note the anomalous calculated calcium chloride reported by How (1869). It is not clear from How's description which spring was sampled, furthermore the reported association with "syenitic rocks" make these springs truly peculiar.

GRANDE ANSE AREA

The Grande Anse Bouguer gravity low is situated near the community of Grand Anse approximately midway between the Port Richmond deposit and the Seaview-St. Peters area (Figs. 7-1 and 7-21). This gravity low (8 mGal)is not as great in magnitude as the other known salt related anomalies in the area and has not been tested by drilling. It is small (less than 2 km wide), slightly oblate in outline and is located on the southeastern side of the major northeastern trending Sporting Mountain Fault. This configuration is very similar to that in the Seaview area and may represent a small low density salt mass related to the Sporting Mountain Fault.

CHAPTER 8 SYDNEY AREA

INTRODUCTION

The Sydney area is located in northeastern Cape Breton County, Cape Breton Island and it coincides approximately with the Sydney sub-basin of Bell (1958). The geology of the Sydney area has been described in maps and reports by Bell and Goranson (1938), Hayes and Bell (1923), and Bell (1958 and 1961a,b). This work forms the basis of the geology of the Carboniferous rocks in the Sydney area. Bell under the direction of L. H. Cole worked as a consultant on the salt-potash exploration program carried out on behalf of Morton Chemical of Canada Limited (Cole, 1961). This exploration in the East Bay area between 1961 and 1962 constitutes the only data on salt in the Sydney area.

GENERAL GEOLOGY

Because of the occurrence of significant coal deposits, the Sydney area has received much attention directed at the geology of the Carboniferous rocks. The Sydney area has a similar basic geological configuration to that described in other Carboniferous depocentres in Nova Scotia. Major structures in the area, as emphasized by the Upper Carboniferous Morien Group, define a series of northeasterly to easterly trending gently plunging folds. To the northeast the rocks are submerged beneath the Atlantic Ocean. To the southwest, older Carboniferous rocks are successively exposed and flank pre-Carboniferous basement blocks forming distinct highlands such as Boisdale Hills, Coxheath Hills and East Bay Hills. These older Carboniferous rocks seem to be represented mainly by Windsor Group with minor outcrop areas of Canso Group (Point Edward Formation), in the area of the Sydney Harbour Syncline and the Bridgeport Anticline. In the area of the Coxheath Hills the major fold structures are complicated by smaller folds including the Dutch Brook Syncline which trends slightly north of east and plunges gently to the east (Fig. 8-1).

Windsor Group rocks form broad outcrop belts in the southwestern part of the area. Contacts with the older pre-Carboniferous basement rocks are locally major faults including the George River Fault on the southeastern border of the Boisdale Hills, and MacKenzie Fault on the southeastern border of the Coxheath Hills (Bell, 1958) (Fig. 8-1). Lower Carboniferous Horton Group rocks were not recognized in the area. In the normal position of the Horton Group, Bell and Goranson (1938) recognized a conglomerate sandstone and shale nonmarine facies of the Windsor Group which they named the Grantmire Member. These rocks are situated adjacent to pre-Carboniferous basement areas including the Coxheath Hills and the northern part of the East Bay Hills. In addition Bell and Goranson (1938) mapped the Grantmire along St. Andrews Channel on the northwestern side of the Boisdale Hills. This unit was extended into adjoining map areas by later workers including Kelley (1967b) who mapped it as Horton Group. Much confusion related to the basal Carboniferous clastic rocks has arisen and a summary of these problems was outlined in the Canso-Bras d'Or area. According to Bell and Goranson (1938), the thick conglomerate deposits, where they lie below marine limestone or sandstone of lower Windsor age and form the base of the Group, were mapped as the Grantmire Member. Weeks (1954) subsequently raised the Grantmire to formation status and applied it to all Windsor conglomerate members that form the base of the Group regardless of whether they were Upper or Lower Windsor age. Bell and Goranson (1938) reported a computed thickness of about 1067 m (3500 ft.) of Grantmire Member in the Coxheath area. It is probable that the Grantmire is mainly assignable to the Horton Group. The unit is indicated by Bell (1958) to be succeeded in the Point Edward area by approximately 230 m (750 ft.) of Upper Windsor marine limestone, red conglomerate and shale (Fig. 8-2).

BOULARDERIE DEPOSIT

LOCATION

The Boularderie deposit is located near Kempt Head at the southern end of Boularderie Island (Figs. 8-3, 8-4 and 1-10) Victoria County, Cape Breton Island (NTS 11K/02E). The area is situated approximately 50 km southwest of Sydney.

The area is readily accessible by paved and unpaved roads connected with Trans-Canada Highway 105 and is bordered on the northwest by Great Bras d'Or Lake and on the southwest by St. Andrews Channel which connect with the Cabot Strait.

The terrain on the Island is gently rolling with hills reaching up to 140 m in elevation.

GEOLOGY

The Boularderie deposit was discovered in a stratigraphic test hole (NSDME Kempt Head 84-1) drilled by the Nova Scotia Department of Mines and Energy in 1984 (Figs. 8-3 and 8-4).

The drillhole is located near the apex (on land) of the Boularderie Syncline on the western side of the Sydney Basin. The Syncline which is defined principally by Late Carboniferous Morien Group plunges gently to the northeast, is fault bound to the northwest and is inferred to have normal contact on the southeast beneath St. Andrews Channel. The synclinal structure is also interpreted to be generally present within the Windsor Group beneath the Morien Group. Extremely deep water (exceeding 250 m) is present in an elongate trough (trench) extending through St. Andrews Channel southwest into Great Bras d'Or Lake. This is inferred to be a solution trench related to karstification and solution collapse of Windsor Group evaporites (especially salt) on the southwestern limb of the Boularderie Syncline (Fig. 8-4 cross-section).

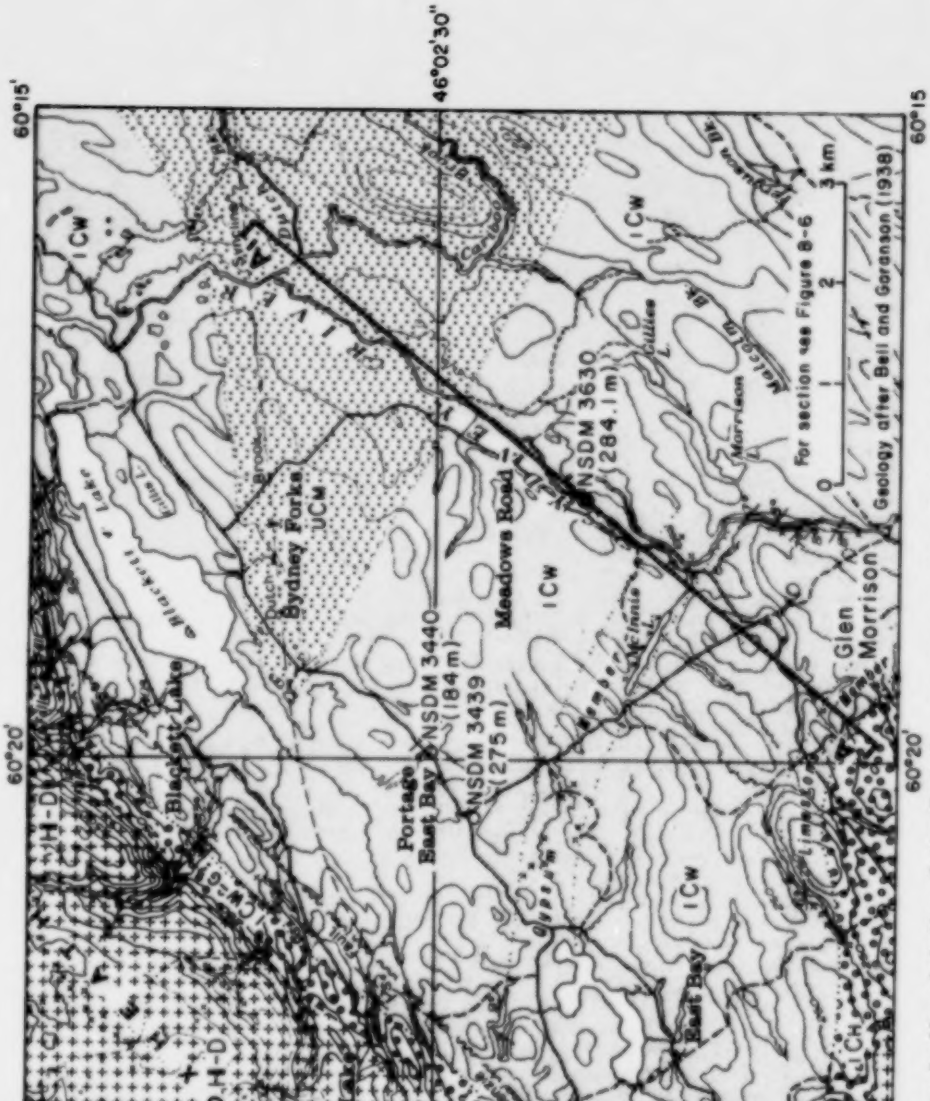

60°15'
46°02'30"
60°20'
60°25'
60°15
60°20'
60°25'
46°02'30"
ICw
ICw
ICw
ICw
Sydney Forks
UCm
Meadows Road
NSDM 3440
(184 m)
NSDM 3439
(275 m)
NSDM 3630
(284.1 m)
Portage
East Bay
Blackett Lake
Gillies Lake
H-D
O-H-D
H-D
H-D
H-D
ICH
ICw-G
McKenzie
East Bay
East Bay
Glen
Morrison
Morrison
Gillies L.
Limestone
RIVER
A
A'
For section see Figure 8-6
0 1 2 3 km
Geology after Bell and Goranson (1938)

Figure 8-1. Geology in the vicinity of the East Bay occurrence, Cape Breton County, Nova Scotia.

LEGEND

UPPER CARBONIFEROUS

MORIEN GROUP

uCM	Undivided: sandstone, conglomerate, shale and coal

PICTOU GROUP

uCI	*INVERNESS FORMATION:* sandstone, shale and coal

RIVERSDALE GROUP

uCR	Undivided: sandstone, conglomerate, shale and coal

CANSO GROUP

uCCa-m	*MABOU FORMATION:* sandstone, siltstone and shale
uCCa	Undivided: sandstone, siltstone and shale
uCg	Gabbro, diabasic gabbro

LOWER CARBONIFEROUS

WINDSOR GROUP

lCW	Undivided: siltstone, gypsum, anhydrite, halite and limestone
lCW-U	Upper: siltstone, gypsum, anhydrite and limestone
lCW-L	Lower: gypsum, anhydrite, siltstone and limestone
lCW-G	*GRANTMIRE FORMATION:* conglomerate and sandstone
lCW-m	Marginal basin beds (Weeks, 1954): conglomerate, sandstone and limestone

HORTON and/or WINDSOR GROUP(S)

lCW-H	Marginal facies: conglomerate and sandstone

HORTON GROUP

lCH-SA	*STRATHLORNE-AINSLIE FORMATION:* sandstone, conglomerate and shale
lCH	Undivided: conglomerate, sandstone and shale

DEVONO-CARBONIFEROUS

DCFB	*FISSET BROOK FORMATION:* mafic and felsic volcanic rocks, conglomerate and sandstone

DEVONIAN

DML	*McADAN LAKE FORMATION:* conglomerate, sandstone, shale and tuff
Dg	Granite, diorite, granodiorite

CAMBRO-ORDOVICIAN

COu	Undivided: conglomerate, grit, sandstone and shale

PROTEROZOIC

Pgd	gd, granodiorite; qd, quartz diorite; v, volcanics

HADRYNIAN

Hg,gd	Granite, granodiorite

FOURCHU GROUP

HF	Undivided: volcanic and sedimentary rocks

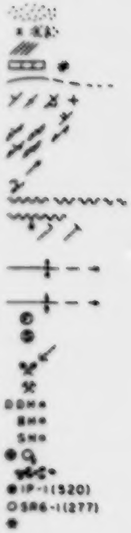
GEORGE RIVER GROUP

HGR	Undivided: metasedimentary rocks

HADRYNIAN-DEVONIAN

H-D	Undivided (may include lCH)

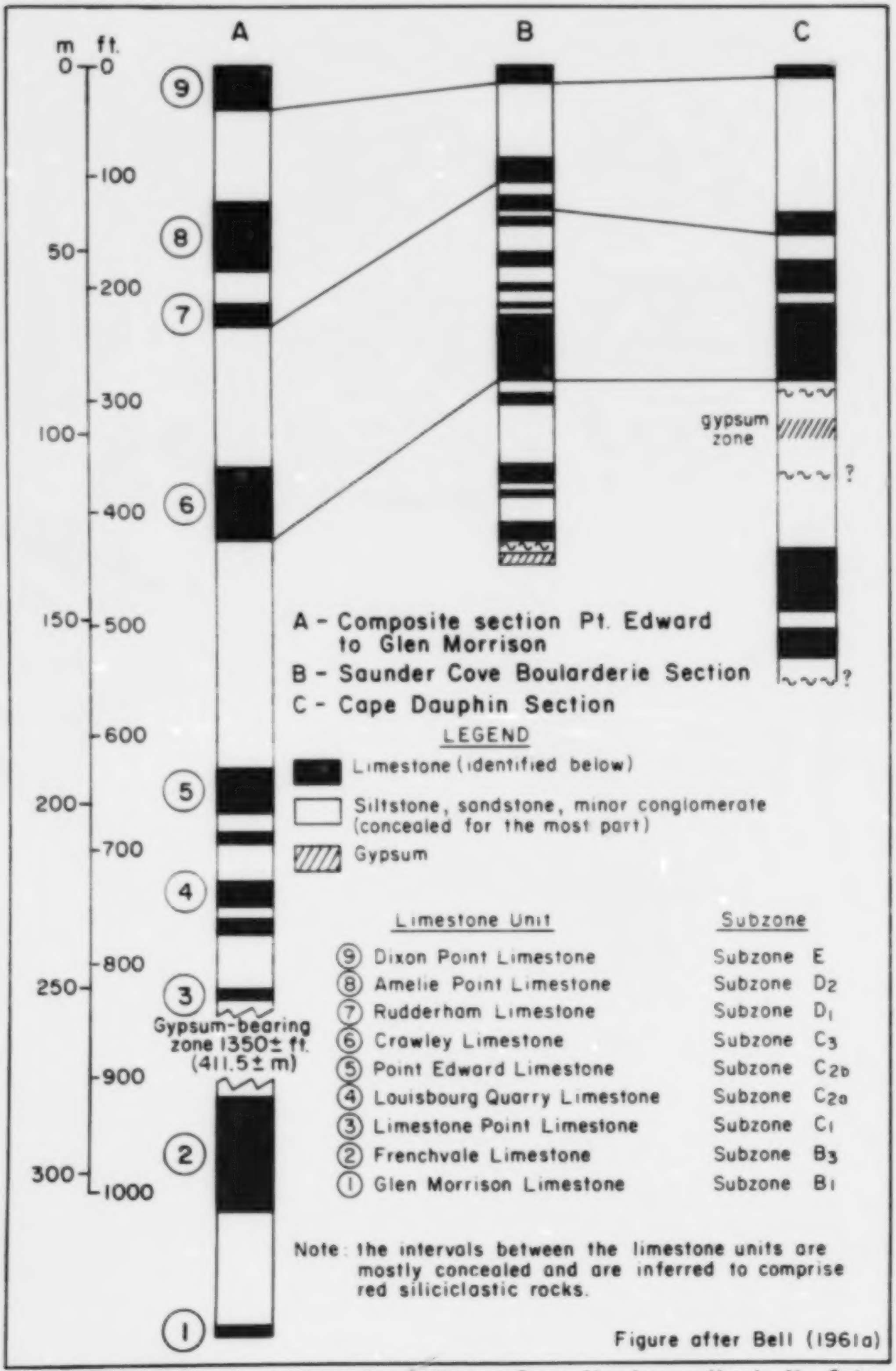
SYMBOLS



Heavily drift-covered area
Rock outcrop, area of outcrop
Limestone or dolomite outcrop (Faribault-Fletcher maps)
Gypsum outcrop
Geological boundary (defined, approximate, assumed)
Bedding, tops known (inclined, vertical, overturned, horizontal)
Bedding, tops unknown (inclined)
Schistosity (inclined, vertical, dip unknown)
Gneissosity (inclined, vertical)
Plunge of minor fold
Drag fold (arrow indicates plunge)
Fault (defined, approximate, assumed)
Fault (solid circle indicates downthrow side)
Joint (inclined, vertical)
Anticline (defined, approximate, arrow indicates direction of plunge)
Syncline (defined, approximate, arrow indicates direction of plunge)
Fossil locality
Spore sample
Glacial striae (ice flow direction known)
Gravel deposit
Quarry
Diamond-drill hole
Borehole
Sinkhole
Salt spring
Observed karst topography
Drillhole intersecting salt; number (depth to salt, metres)
Drillhole without salt; number (Total depth, metres)
Drillhole location precise to 150 m

MINERALS

Anhydrite	ah	Limestone	lst
Gypsum	gyp	Pyrite	py
Lead	Pb	Zinc	Zn
Celestite	Sr		

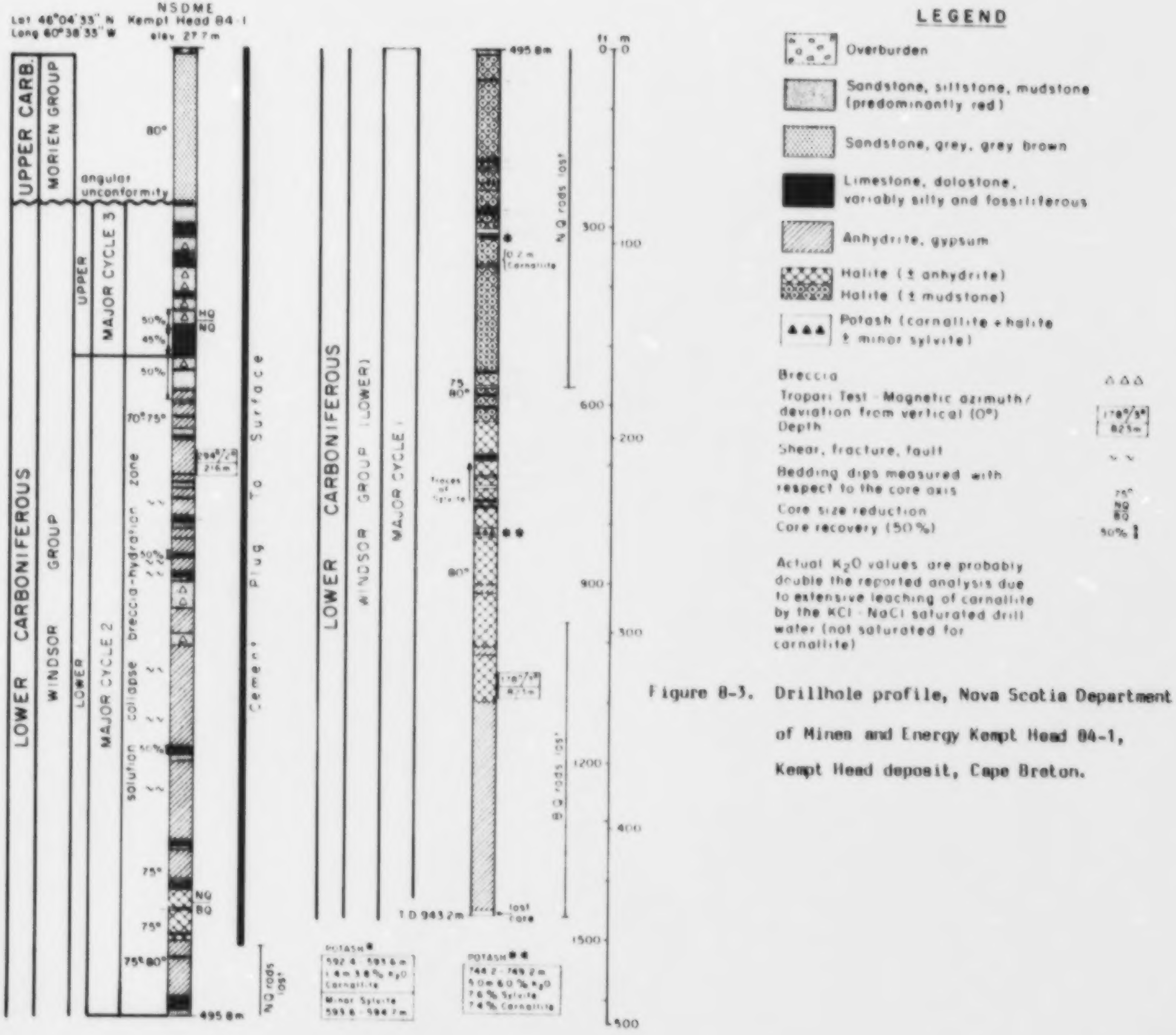

m ft.
0 0
100
50
200
300
100
400
150 500
600
200
700
800
250
900
300 1000
A
B
C
⑨
⑧
⑦
⑥
⑤
④
③
②
①
Gypsum-bearing zone 1350± ft. (411.5± m)
gypsum zone
?
?
A - Composite section Pt. Edward to Glen Morrison
B - Saunder Cove Boularderie Section
C - Cape Dauphin Section
LEGEND
Limestone (identified below)
Siltstone, sandstone, minor conglomerate (concealed for the most part)
Gypsum

Limestone Unit	Subzone
⑨ Dixon Point Limestone	Subzone E
⑧ Amelie Point Limestone	Subzone D_2
⑦ Rudderham Limestone	Subzone D_1
⑥ Crawley Limestone	Subzone C_3
⑤ Point Edward Limestone	Subzone C_{2b}
④ Louisbourg Quarry Limestone	Subzone C_{2a}
③ Limestone Point Limestone	Subzone C_1
② Frenchvale Limestone	Subzone B_3
① Glen Morrison Limestone	Subzone B_1

Note: the intervals between the limestone units are mostly concealed and are inferred to comprise red siliciclastic rocks.

Figure after Bell (1961a)

Figure 8-2. Correlation and stratigraphy of Windsor Group limestone units in the Sydney Area, Cape Breton.



Lat 46°04'33" N
Long 60°38'33" W
NSDME
Kempt Head 84-1
elev. 27.7 m
UPPER CARB.
MORIEN GROUP
angular unconformity
LOWER CARBONIFEROUS
WINDSOR GROUP
UPPER
LOWER
MAJOR CYCLE 3
MAJOR CYCLE 2
solution collapse breccia-hydration zone
80°
50%
45%
50%
NQ
NQ
70°75°
294°/2°
216 m
50%
50%
75°
NQ
BQ
75°
75°80°
495.8 m
NQ rods lost
Cement Plug To Surface
LOWER CARBONIFEROUS
WINDSOR GROUP (LOWER)
MAJOR CYCLE 1
T.D. 943.2 m
495.8 m
0.2 m Carnallite
75
80°
traces of sylvite
80°
lost core
POTASH ●
592.4 - 593.6 m
1.4 m 3.8 % K2O
Carnallite
Minor Sylvite
593.6 - 594.7 m
POTASH ● ●
748.2 - 749.2 m
5.0 m 6.0 % K2O
7.6 % Sylvite
7.4 % Carnallite
178°/3°
825 m
NQ rods lost
BQ rods lost
ft
m
0
300
600
900
1200
1500
0
100
200
300
400
500
LEGEND
Overburden
Sandstone, siltstone, mudstone (predominantly red)
Sandstone, grey, grey brown
Limestone, dolostone, variably silty and fossiliferous
Anhydrite, gypsum
Halite (± anhydrite)
Halite (± mudstone)
Potash (carnallite + halite ± minor sylvite)
Breccia
Tropari Test - Magnetic azimuth/deviation from vertical (0°) Depth
Shear, fracture, fault
Bedding dips measured with respect to the core axis
Core size reduction
Core recovery (50 %)
75°
NQ
BQ
50%
Actual K2O values are probably double the reported analysis due to extensive leaching of carnallite by the KCl - NaCl saturated drill water (not saturated for carnallite)

Figure 8-3. Drillhole profile, Nova Scotia Department of Mines and Energy Kempt Head 84-1, Kempt Head deposit, Cape Breton.

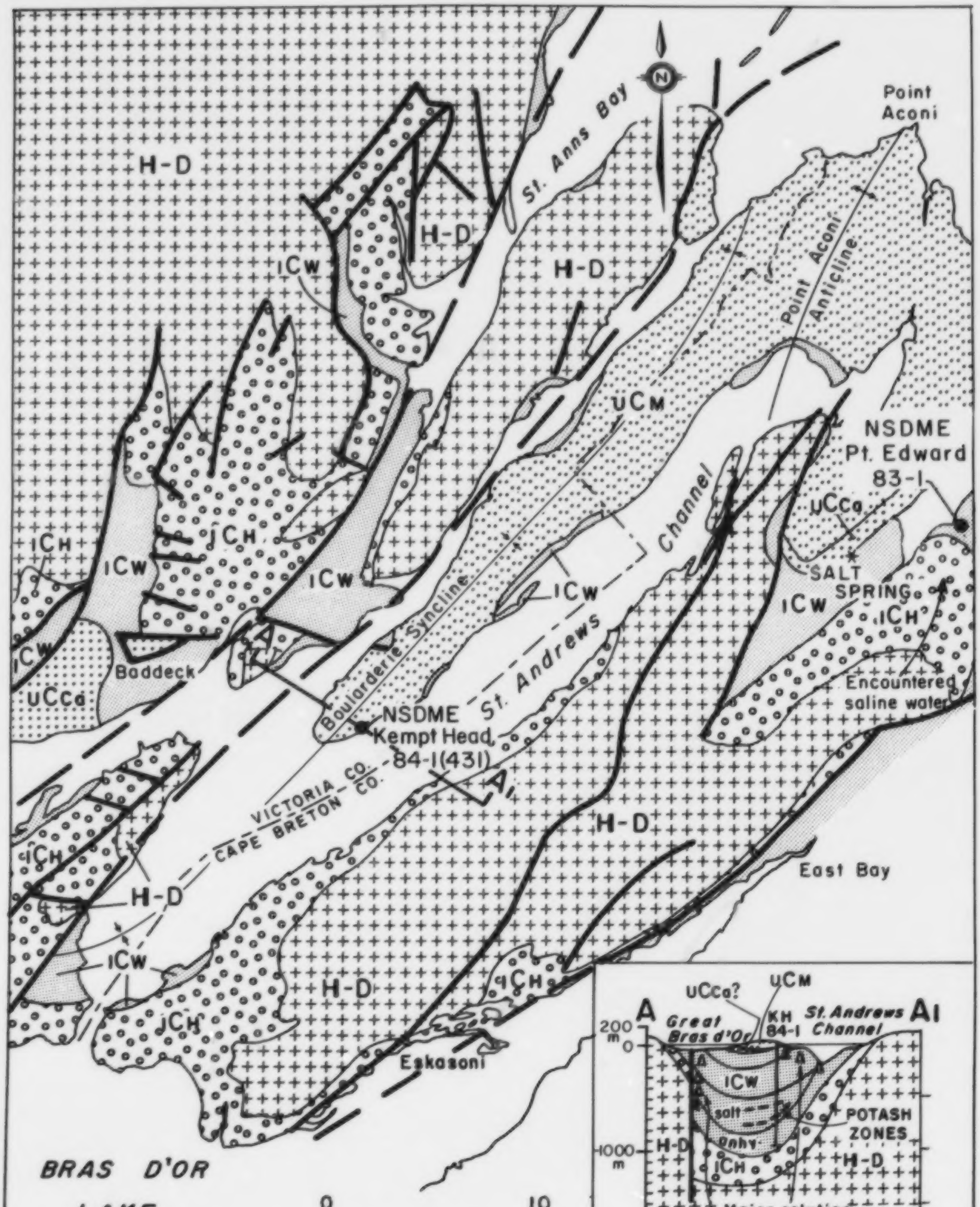

H-D
St. Anns Bay
N
Point Aconi
H-D
ICw
H-D
Point Aconi Anticline
uCM
NSDME Pt. Edward 83-1
uCCa
ICH
ICw
ICH
ICw
Channel
SALT SPRING
ICw
ICH
Boularderie Syncline
ICw
St. Andrews
A
Baddeck
uCCa
Encountered saline water
NSDME Kempt Head 84-1(431)
A1
VICTORIA CO.
CAPE BRETON CO.
H-D
ICH
H-D
East Bay
ICw
H-D
ICH
ICH
Eskasoni
BRAS D'OR LAKE
0
10
km
For legend see Figure 8-1
uCCa?
uCM
A
Great Bras d'Or
KH 84-1
St. Andrews Channel
A1
200 m
0
ICw
salt
anhy
POTASH ZONES
H-D
1000 m
ICH
H-D
Major solution collapse breccia zones

Figure 8-4. Geological map and cross-section, Kempt Head deposit, Cape Breton.

Stratified salt was intersected in Kempt Head 84-1 (Fig. 8-4) at 431.2-457.8 m (1415-1502 ft.) (Cycle 2) and the Major Cycle 1 salt section from 495.8-832.9 m (1627-2733 feet). Bedding dips in the drillhole are gentle to moderate ranging from 10°- 25°. The salt above 687 m (2254 feet) is generally of low grade (less than 70% NaCl) with mudstone the dominant impurity. The grade from 687.0 m to 832.9 m (2254-2733 feet) is estimated at 90 to 95 per cent NaCl. Two significant potash zones were intersected. One occurs at 592.2-593.6 m (1942.9-1947.5) comprising 1.4 m (4.6 ft.-apparent thickness) of carnallite and halite with minor sylvite (3.84% K_2O), and a thicker zone is located at 744.2-749.2 m (2441.6-2458.0 feet) comprising 5.0 m (16.4 ft.-apparent thickness) of carnallite, halite and minor sylvite (6.0% K_2O). These potash zones are very similar geologically to the A subzone (Major Cycle 1) potash at the Malagawatch and Orangedale deposits described by Dekker (1982). The Windsor Group structural geology however appears to be much less complicated.

Major salt horizons were not expected to be present in the Boularderie Syncline. Their presence in the discovery drillhole may indicate a wider distribution of saline evaporites in the deeper parts of the Sydney area. Minor salt is known in the East Bay occurrence and saline water was encountered in the NSDME Point Edward 83-1 drillhole near Point Edward. Further drilling and gravity surveys will be required to assess the extent and significance of salt and potash in the Boularderie area.

EAST BAY OCCURRENCE

The East Bay occurrence (NTS 11K/01) is situated approximately five kilometres east of the community of East Bay, Cape Breton County (Figs. 1-10 and 8-1). East Bay is located approximately 18 km south of Sydney.

The area is readily accessible through a series of paved and unpaved roads connected with Highway No. 4 which runs between Sydney River and Port Hawkesbury.

The terrain in the occurrence area is typical of the Carboniferous Sydney Lowlands where elevations rarely exceed 100 m in gently rolling hills. The highland areas are the Coxheath Hills to the northwest where elevations locally exceed 200 m, and the East Bay Hills to the south where elevations locally exceed 160 m.

HISTORICAL BACKGROUND

The first reported exploration for salt in the East Bay area was undertaken for Morton Chemical of Canada Limited in 1961-1962. Previous regional investigations for salt and potash, including that by Hayes (1931) did not contain references to salt springs or to exploration activity in the area.

The exploration work of Morton Chemical was carried out under the direction of Cole (1961) with W. A. Bell contracted to supervise the on-site geological work and drilling. Bell (1961b) described the basic geology in the area and correlated the stratigraphy of the rocks intersected in the three exploration drillholes with the stratigraphic section which he erected for the Sydney area (Bell, 1961a) (Figs. 8-2 and 8-5).

GEOLOGY

The geology in the East Bay area was described and mapped by Bell and Goranson (1938) (Fig. 8-1), and Bell (1961a). The major geological features in the vicinity of the occurrence (Fig. 8-1) include the Dutch Brook Syncline which comprises gently folded and gently plunging (eastward) Carboniferous strata assigned to the Windsor and Morien Groups (Fig. 8-6). The strata on the southern limb of the Dutch Brook Syncline onlap pre-Carboniferous basement granitic rocks of the East Bay Hills. Horton Group rocks were not mapped in the area. Instead, a basal terrigenous facies of the Windsor Group, the Grantmire Member, was recognized by Bell and Goranson (1938). The drilling and subsequent revision of the stratigraphy in other areas (Kelley 1967b) suggest instead that much of what was mapped as Grantmire should be assigned to the Horton Group (Fig. 8-6).

The western and northwestern border of the Dutch Brook Syncline is truncated by a major fault named the McKenzie Fault. This Fault is an extension of the Coxheath Fault which extends northeasterly into the Sydney River area.

The basic stratigraphy in the area is summarized in Figures 8-2 and 8-5 and cross-section A-A_1 (Fig. 8-6) summarizes the interpreted geology in the area. The Windsor Group intersected in NSDM 3439, 3440, and 3630 drilled by Morton Chemical of Canada Limited (Bell, 1961b)is an interbedded succession of evaporite (gypsum and anhydrite), red and grey-green siltstone, sandstone, locally fine conglomerate, and fossiliferous marine limestone (Fig. 8-5). Dominantly grey sandstone and shale with interbeds of anhydrite occur at the base of the section. These strata are similar to the lithology of the Meaghers Grant Formation described by Giles and Boehner (1979), and overlie a fossiliferous basal carbonate which has a bank type facies at Glen Morrison. This basal limestone unit may be correlative with the Gays River Formation of Giles et al. (1979). The stratigraphic setting in this area appears to be similar to that in the Musquodoboit Basin described by Boehner (1977b), and Giles and Boehner (1979). The main Windsor Group salt unit, if present in the East Bay area, should occur deeper in the Dutch Brook Syncline (Fig. 8-6). The thin salt intersected in NSDM 3630 at 284.1-286.8 m (632-641 ft.) is interpreted to be a thin lens or tongue of the main salt. The salt is described as a 25 per cent halite mixture with 75 per cent anhydrite, limestone and sandstone.

Geophysical and geochemical data are not available for the East Bay occurrence. Salt springs have not been reported in the area.

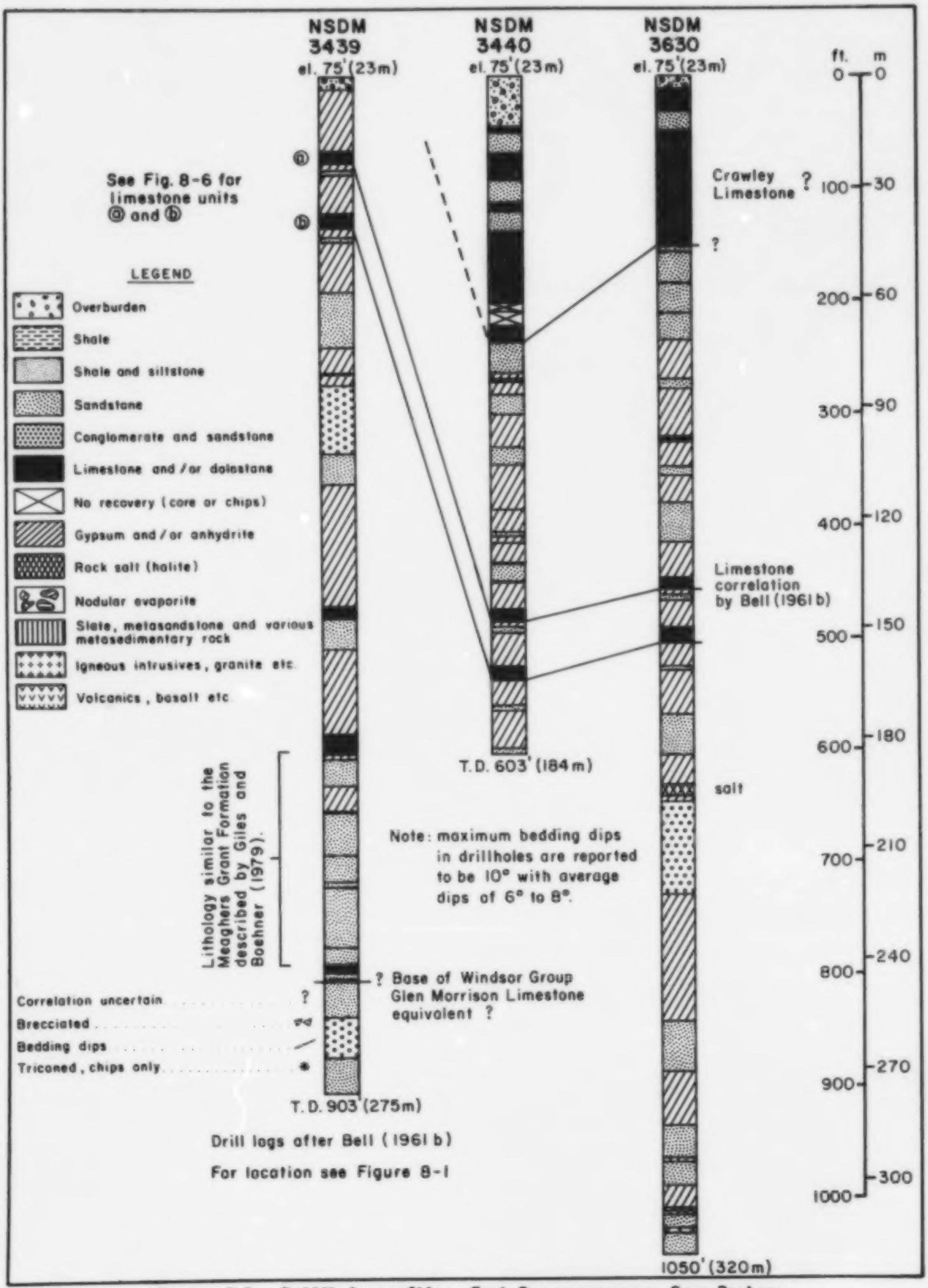
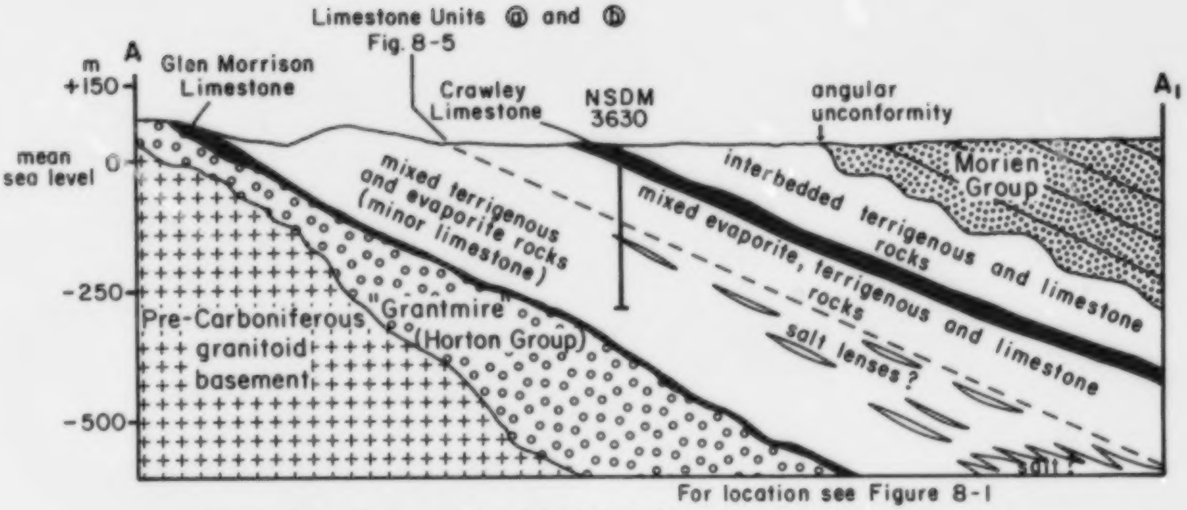

NSDM 3439
el. 75'(23m)
NSDM 3440
el. 75'(23m)
NSDM 3630
el. 75'(23m)
ft.
m
0
100
200
300
400
500
600
700
800
900
1000
0
30
60
90
120
150
180
210
240
270
300
See Fig. 8-6 for limestone units ⓐ and ⓑ
ⓐ
ⓑ
Crawley Limestone ?
?
Limestone correlation by Bell (1961b)
salt
LEGEND
Overburden
Shale
Shale and siltstone
Sandstone
Conglomerate and sandstone
Limestone and/or dolostone
No recovery (core or chips)
Gypsum and/or anhydrite
Rock salt (halite)
Nodular evaporite
Slate, metasandstone and various metasedimentary rock
Igneous intrusives, granite etc.
Volcanics, basalt etc.
Lithology similar to the Meaghers Grant Formation described by Giles and Boehner (1979).
T.D. 603' (184m)
Note: maximum bedding dips in drillholes are reported to be 10° with average dips of 6° to 8°.
? Base of Windsor Group Glen Morrison Limestone equivalent ?
Correlation uncertain ?
Brecciated
Bedding dips
Triconed, chips only *
T.D. 903' (275m)
1050' (320m)
Drill logs after Bell (1961b)
For location see Figure 8-1

Figure 8-5. Drillhole profiles, East Bay occurrence, Cape Breton.


Limestone Units ⓐ and ⓑ
Fig. 8-5
m
A
+150
Glen Morrison
Limestone
Crawley
Limestone
NSDM
3630
angular
unconformity
A₁
mean
sea level
0
Morien
Group
mixed terrigenous
and evaporite rocks
(minor limestone)
interbedded terrigenous and limestone
rocks
mixed evaporite, terrigenous and limestone
rocks
-250
Pre-Carboniferous
granitoid
basement
"Grantmire"
(Horton Group)
salt lenses ?
-500
salt ?

For location see Figure 8-1

Figure 8-6 Cross-section A-A of East Bay occurrence, Cape Breton.

ECONOMIC CONSIDERATIONS

The East Bay occurrence consists of a mixture of halite, anhydrite, sandstone and limestone intersected between 284.1 and 286.8 m (932 and 941 ft.) in drillhole NSDM 3630. Two other drillholes in the area did not intersect salt. There are no salt springs known in the area.

The occurrence is considered to be of little economic significance now, but further exploration drilling would be required to determine if more salt is present deeper in the Dutch Brook Syncline.

CHAPTER 9

CHETICAMP-MARGAREE AREA

The presence of salt has not been established by drilling in the Cheticamp-Margaree area (Fig. 1-10), but it is inferred to the present, at least locally, based on the occurrence of a salt spring near Lake O'Law (Fig. 9-1 and 9-2). The geology of the Cheticamp-Margaree area, on portions of NTS 11K/06, 11K/07, 11K/10 and 11K/11, has been described in maps and reports by Cameron (1948), MacLaren (1956a,b), Kelley (1960) and Currie (1977), and unpublished Nova Scotia Department of Mines and Energy assessement file reports from petroleum exploration companies including Imperial Oil, and Lion Oil and Refining. In addition to geological surveys, geophysical surveys including gravity and seismic have been made in parts of the area. A gravity survey by Seismograph Service Corporation (1959) for Imperial Oil Limited outlines several Bouguer minima coincident with the Windsor Group outcrop areas (Fig. 9-1). One such area is the Margaree structural basin. Although gravity coverage is imcomplete, a salt spring on the eastern border near Lake O'Law indicates salt is probably present in at least part of the area.

Another Bouguer gravity low is located immediately to the west of the Margaree low and is also coincident with an outcrop belt of Windsor Group in the area between Margaree Forks and South West Margaree (Fig. 9-1). The coincidence of a gravity low and Windsor Group outcrop areas is commonly indicative of the presence of salt.

LAKE O'LAW (NORTH EAST MARGAREE) SALT SPRING

The presence of salt in the Margaree Valley is indicated by a salt spring situated near Lake O'Law (Fig. 9-1). This spring was located by staff of the Nova Scotia Department of Mines who were carrying out geochemical and geological surveys in the area in 1973 (J. Fowler, personal communication). The geology in the area has been described and mapped by Cameron (1948), Kelly (1960) and MacNabb et al. (1976).

In summary, the Windsor Group outcrop area has all borders, except the western one, defined by faults. The western border is apparently conformable with Horton Group. Numerous sinkholes and gypsum outcrops occur along the western border. Outcrops of Windsor Group rocks are very scarce in the major part of the area. Attempts have not been make to subdivide the Windsor Group strata and subsurface drillhole data are not available for this area.

Although gravity survey data are not complete in the area, a substantial Bouguer gravity low is indicated on a gravity map prepared by Seismograph Service Corporation (1959). This gravity low may be caused by the presence of low density rock such as salt. Exploration drilling will be required to confirm the presence, quality and quantity of salt in this area.

GEOCHEMISTRY

The following unpublished chemical analyses of the salt spring at Lake O'Law (Table 9-1) was obtained in 1973 by J. Fowler of the Nova Scotia Department of Mines. This composition is typical of low $CaSO_4$-bearing salt springs in Nova Scotia.

Table 9-1. Chemical analysies, Lake O'Law spring, Inverness County.

	ppm
Calcium	118.8
Magnesium	35.28
Sodium	2700
Potassium	13
Chloride	3941.2
Manganese (total)	0.02
Iron (total)	0.24

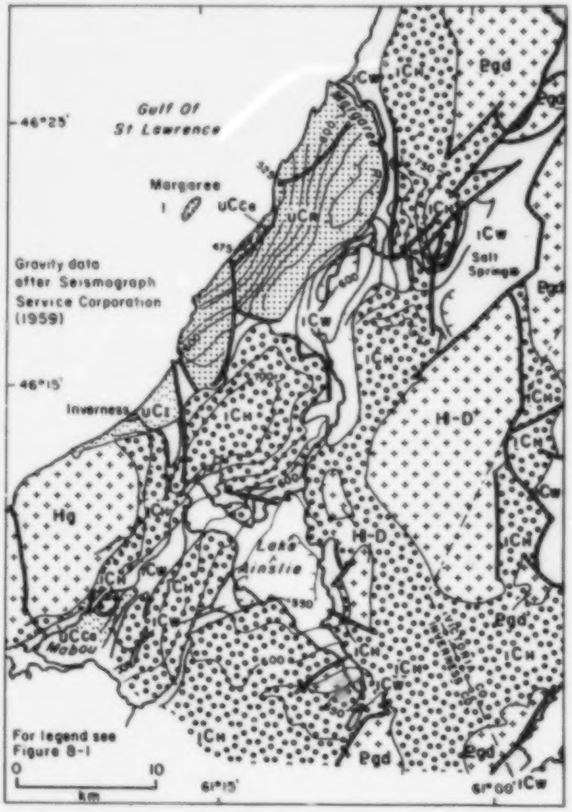
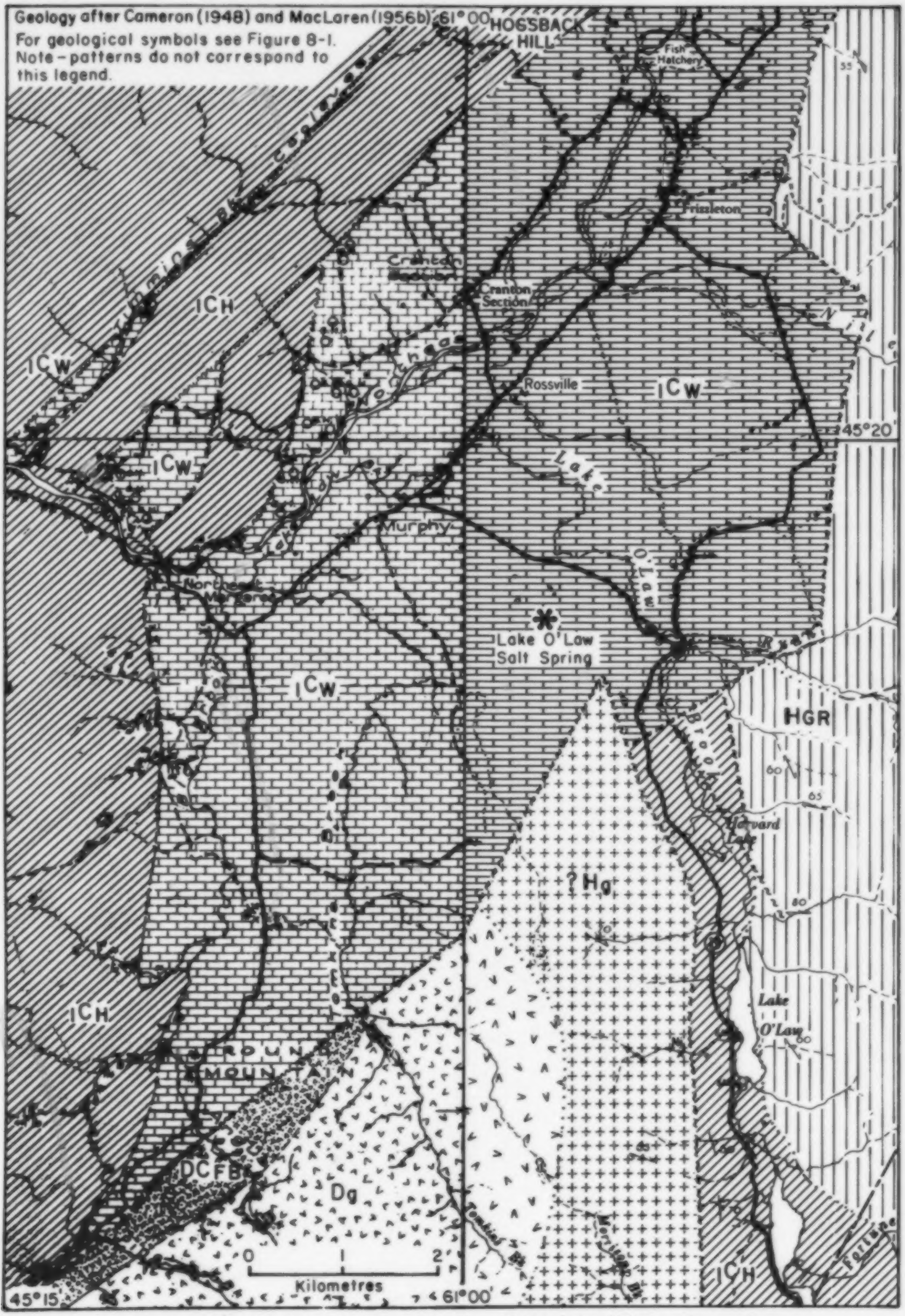


Figure 9-1.

Gravity anomaly map, Margaree area, Cape Breton Island,Nova Scotia.



Geology after Cameron (1948) and MacLaren (1956b).
For geological symbols see Figure 8-1.
Note – patterns do not correspond to this legend.

61°00
HOGSBACK HILL
Fish Hatchery
55
Frizzleton
Cranton Section
lCH
lCW
lCW
Rossville
lCW
45°20'
Lake
Murphy
O'Law
Northeast Margaree
Lake O'Law Salt Spring
lCW
HGR
60
65
Harvard Lake
?Hg
80
Lake O'Law
60
lCH
ROUND MOUNTAIN
DCFB
Dg
0
1
2
Kilometres
45°15'
61°00'
lCH

Figure 9-2. Geology in the vicinity of the Lake O'Law salt spring.

CHAPTER 10

CAPE NORTH AREA

In the Cape North area, Windsor Group rocks have been mapped at Pleasant Bay, Bay St. Lawrence, Dingwall and Ingonish. The geology of this area is included in maps and reports by Neale (1963a,b and 1964a,b). Most of the outcrop areas are very small and have minimal cover of post Windsor Group strata so the onshore potential for salt is not considered to be very promising.

Salt springs have not been reported from the Cape North area and gravity survey data are not available. The Bay St. Lawrence area offers the best possibility for salt in a nearshore area because it is the only area with significant post Windsor Group cover (Canso Group).

SELECTED BIBLIOGRAPHY

Amax Exploration Limited
1975: Miscellaneous drill logs and maps; Nova Scotia Department of Mines and Energy, Assessment Report 11E/08 40-B-19(01).

Anderle, J. P., Crosby, K. S. and Waugh, D. C. E.
1979: Potash at Salt Springs New Brunswick; Economic Geology, v. 74, p. 389-396.

Aumento, F.
1964: Authigenic minerals and preliminary investigations of the evaporite deposit at Pugwash, Nova Scotia; Nova Scotia Research Foundation, unpublished Report 13-64, 39 p.

Avison, A. T.
1972: Stewiacke project, Nova Scotia, progress report to December 20, 1972; Nova Scotia Department of Mines and Energy, Assessment Report 11E/03 58-D-43(01).

1979: Stewiacke zinc project, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/03 58-D-43(01).

Baar, C. A.
1965: Bromine investigations on Eastern Canada salt deposits; in Second Symposium on Salt, ed. J. L. Rau; Northern Ohio Geological Society, p. 276-292.

1966: Report of the first phase of geochemical investigation for Potash Exploration Project; Nova Scotia Research Foundation, Report No. 2-66.

Bancroft, M. F.
1938: Salt deposits at Malagash, Nova Scotia; Annual Report on the Mines, Pt. 2, 1937; Nova Scotia Department of Mines Annual Report, p. 4-10.

1957: Drillhole plots, Dominion Rock Salt Company, Mount Denson No. 1 and No. 2; unpublished, Nova Scotia Department of Mines and Energy.

Barnes, N. E.
1976: The areal geology and Holocene history of the eastern half of Mahone Bay, Nova Scotia; unpublished M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia; Nova Scotia Department of Mines and Energy Thesis 013, 125 p.

Barry, G. S.
1979: Salt; in Canadian Minerals Yearbook, 1979; Canada Department of Energy, Mines and Resources.

Barss, M. S. and Hacquebard, P. A.
1967: Age and stratigraphy of the Pictou Group in the Maritime Provinces as revealed by fossil spores; in Collected Papers in Geology of the Atlantic Region; Geological Association of Canada, Special Paper No. 4, p. 267-282.

Barss, M. S., Hacquebard, P.A. and Howie, R. D.
1963: Palynology and stratigraphy of some Upper Pennsylvanian and Permian rocks of the Maritime Provinces; Geological Survey of Canada, Paper 63-3, 13 p.

Beaver Geophysical Services Limited
1965: Reflection seismograph survey of Malagash area, Pugwash, Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 049.

Bell, W. A.
1926: Carboniferous formations of Northumberland Strait, Nova Scotia; in Geological Survey of Canada, Summary Report 1924, Part C, p. 142-180.

1929: Horton-Windsor district, Nova Scotia; Geological Survey of Canada, Memoir 155, 268 p.

1944: Carboniferous rocks and fossil floras of northern Nova Scotia; Geological Survey of Canada, Memoir 238, 277 p.

1945: Shinimicas map sheet, Cumberland County, Nova Scotia; Geological Survey of Canada, Map 842A.

1958: Possibilities for occurrence of petroleum reservoirs in Nova Scotia; Nova Scotia Department of Mines Report, 177 p.

1960: Mississippian Horton Group of type Windsor-Horton district, Nova Scotia; Geological Survey Canada, Memoir 314, 58 p.

1961a: Limestones of the Late Mississippian Windsor Group in Sydney area, Cape Breton, Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 002, 61 p.

1961b: Report on evaporite deposits in the Sydney Forks district, Sydney area, Nova Scotia; in Report on Drilling for Evaporites in the Sydney Forks Area of Cape Breton; Nova Scotia Department of Mines and Energy, Assessment Report 11K/01 40-C-90(01).

Bell, W. A.

1964: Report on strata cut in borehole No. 1 Walton (TZ136-1) of New Jersey Zinc Exploration Company (Canada) Limited; Nova Scotia Department of Mines and Energy, Assessment Report 21H/01D 27-I-51(07)

Bell, W. A. and Goranson, E. A.

1938: Sydney sheet (west half), Cape Breton and Victoria Counties, Nova Scotia· Geological Survey of Canada, Geological Map 360A.

Belt, E. S.

1962: Stratigraphy and sedimentology of the Mabou Group (Middle Carboniferous), Nova Scotia, Canada; unpublished Ph.D thesis, Yale University, New Haven, Connecticut, 312 p.

1964: Revision of Nova Scotia Middle Carboniferous units· American Journal of Science, v. 262, p. 653-673.

1965: Stratigraphy and paleogeography of Mabou Group and related Middle Carboniferous facies, Nova Scotia, Canada; Bulletin Geological Society of America, v. 76, p. 777-802.

1968: Post-Acadian rifts and related facies, Eastern Canada; in Studies of Appalachian Geology: Northern and Maritime, eds. Ean Zen et al.; Interscience Publication, New York, p. 95-113.

Benson, D. G.

1967: Geology of Hopewell map area, Nova Scotia; Geological Survey of Canada, Memoir 343, 58 p.

1970: Notes to accompany geological maps of the Antigonish and Cape George map areas, Nova Scotia; Geological Survey of Canada, Paper 70-8 (Report and maps 2-1970 and 3-1970).

1974: Geology of the Antigonish Highlands, Nova Scotia; Geological Survey of Canada, Memoir 376, 92 p.

Bidgood, D. E. T.

1970: The distribution and diapiric nature of some Nova Scotia evaporites, a geophysical evaluation; in The Third Symposium on Salt; Northern Ohio Geological Society, p. 298-304.

Bidgood, D. E. T. and Blanchard, J. E.

1967: Geophysical investigations of evaporites in Nova Scotia; in Mining and Groundwater Geophysics 1967; Geological Survey of Canada, Economic Geology Report No. 26, p. 497-503.

Black, D.

1979: Base metals, Ohio, Antigonish County, Nova Scotia; Report to Cuvier Mines Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09A 07-8-23(05).

1981: Potash, Addington Forks, Antigonish County, Nova Scotia; Cuvier Mines Limited, Report on drilling; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09A 40-8-80(02).

Blanchard, J. E.

1957: Report on geophysical exploration, western Hants County, Nova Scotia; Magnet Cove Barium Corporation; Nova Scotia Research Foundation Corporation, Report 1-57; Nova Scotia Department of Mines and Energy, Open File Report 330.

Boehner, R. C.

1977a: First report on progress Resource Development Planning Project No. 1, Salt Study; Nova Scotia Department of Mines and Energy, Open File Report 249.

1977b: The lower Carboniferous stratigraphy of the Musquodoboit Valley, central Nova Scotia; unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia; Nova Scotia Department of Mines and Energy Thesis 029, 204 p.

1977c: Multiple repetition of a single carbonate horizon in the lower part of the Windsor Group, northwest Kennetcook map area; in Mineral Resources Division, Report of Activities, 1976; Nova Scotia Department of Mines, Report 77-1, p. 125-133.

1978a: Assessment of salt deposits in Nova Scotia; in Mineral Resources Division, Report of Activities, 1977; Nova Scotia Department of Mines and Energy, Report 78-1, p. 53-56.

1978b: Preliminary salt file compilation; Nova Scotia Department of Mines and Energy, Open File Report 337.

1984: Stratigraphy and depositional history of marine evaporites in the Lower Carboniferous Windsor Group, Shubenacadie and Musquodoboit Structural Basins, Nova Scotia, Canada; Ninth International Congress of Carboniferous Stratigraphy and Geology, Urbana, Illinois, 1979; Compte Rendu, v. 3, p. 163-178.

Boehner, R. C.

1980a: Geology, geochemistry and geophysics of the Shubenacadie-Stewiacke salt deposit, Hants and Colchester Counties, Nova Scotia; in Mineral Resources Division, Report of Activities, 1979; Nova Scotia Department of Mines and Energy, Report 80-1, p. 165-186.

1980b: Preliminary report on the Carboniferous geology of the Antigonish Structural Basin, Antigonish County, Nova Scotia; in Mineral Resources Division, Report of Activities, 1979; Nova Scotia Department of Mines and Energy, Report 80-1, p. 147-163.

1981a: History of potash exploration in Nova Scotia; in Mineral Resources Division, Report of Activities, 1980; Nova Scotia Department of Mines and Energy, Report 81-1, p. 141-152.

1981b: Preliminary report on the geology and mineral deposits of the Loch Lomond Basin, Cape Breton Island; in Mineral Resources Division, Report of Activities, 1980; Nova Scotia Department of Mines and Energy, Report 81-1, p. 153-165.

1983: Loch Lomond Basin, Cape Breton Island, Windsor Group Project - an update; Mines and Minerals Branch, Report of Activities, 1982; Nova Scotia Department of Mines and Energy, Report 83-1, p. 97-104.

1985: Windsor Group salt and potash in Nova Scotia, Canada; in Sixth International Symposium on Salt, Toronto, 1983; The Salt Institute, Virginia, U.S.A.; v. 1, p. 99-113.

Boehner, R. C. and Giles, P. S.

1976: The lower Carboniferous stratigraphy of the Musquodoboit Valley, Nova Scotia; Abstract in Mineral Resources Division, Report of Activities, 1975; Nova Scotia Department of Mines, Report 76-2, p. 99-100.

1982: Geological map of the Antigonish Basin, Nova Scotia; Nova Scotia Department of Mines and Energy, Map 82-2, Scale 1:50 000.

Boehner, R. C. and Nance, R. D.

1978: Petrology of salt core, Vacherie Dome; in An Investigation of the Utility of Gulf Coast Salt Domes for the Storage or Disposal of Radioactive Wastes; Institute for Environmental Studies, Louisiana State University, Baton Rouge, Louisiana, v. 2, p. 57-66.

Borchert H. and Muir, R. O.

1964: Salt Deposits, the Origin, Metamorphism and Deformation of Evaporites; D. Van Nostrand Company, Limited, London.

Boucot, A. J., Dewey, J. F., Dineley, D. L., Fletcher, R., Fyson, W. K., Griffin, J. G., Hickox, C. F., McKerrow, W. S. and Ziegler, A. M.

1974: Geology of the Arisaig area; Geological Society of America, Special Paper 139, 191 p.

Boyd, B. W.

1976: Salt; in Canadian Minerals Yearbook, 1975; Canada Department of Energy, Mines and Resources, Mineral Report 25.

1977: Salt; in Canadian Minerals Yearbook, 1976; Canada Department of Energy, Mines and Resources, Mineral Report 26, p. 443-450.

Boyle, R. W.

1963: Geology of the barite, gypsum, manganese, and lead-zinc-copper-silver deposits of the Walton-Cheverie area, Nova Scotia; Geological Survey of Canada, Paper 62-25.

1972: The geology, geochemistry, and origin of the barite, manganese, and lead-zinc-copper-silver deposits of the Walton-Cheverie area, Nova Scotia; Geological Survey of Canada, Bulletin 166, 181 p.

Burr, S. V.

1968: Summary report on joint venture, Hilden-Beaver Brook, Colchester County, Nova Scotia; unpublished report to the directors of Peel Elder Limited and New Senator-Rouyn Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11E/06B 60-D-26(02).

Burton, W.

1974: Report on diamond-drilling, Ohio copper property, Antigonish County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09A 13-B-23(02).

1977: Annual report, Lower South River; report for U.S. Borax and Chemical Corporation; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12B 07-B-35(02).

Calder, J.H.

1980: Coal exploration in the Springhill coalfield; in Mineral Resources Division, Report of Activities, 1979; Nova Scotia Department of Mines and Energy, Report 80-1, p. 41-50.

Cameron, H. L.

1948: Margaree and Cheticamp map areas, Nova Scotia; Geological Survey of Canada, Paper 48-11.

1956: Tectonics of the Maritime area; Transactions Royal Society of Canada, v. 50, p. 45-51.

Cameron, R. A.

1965a: Potash exploration program, progress report #3; Nova Scotia Department of Mines and Energy, Open File Report 049.

1965b: Potash exploration program progress report #2; Nova Scotia Department of Mines and Energy, Open File Report 049.

1965c: Potash exploration program, progress report #1; Nova Scotia Department of Mines and Energy, Open File Report 049.

1966: Preliminary geological map, Wallace-Malagash area, Cumberland County; Nova Scotia Department of Mines and Energy, Open File Report 049.

1967: Potash project, geological report, summer 1966; Nova Scotia Department of Mines and Energy, Open File Report 049.

Campbell, D. A.

1967: Summary report, exploration for sulphur, Hilden Project, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/06B 60-D-26(02).

Canada Department of Energy, Mines and Resources

1941: Flotation concentration of sylvite in a sylvite-halite product from a fractional crystallization of a brine from the Malagash Salt Company, Malagash, Nova Scotia; Report to the Ore Dressing and Metallurgical Laboratories, Investigation No. 1034; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 42-E-19(00).

1977: Bouguer anomaly map; Gravity Compilation Division, Canada Department of Energy, Mines and Resources, Open File Report 77-6, scale 1:50 000.

Canadian Salt Company Limited

1976: Unpublished mine plan, 630 foot level Pugwash Mine, Cumberland County, Nova Scotia; Nova Scotia Department of Mines and Energy, Halifax.

1978: Pugwash Mine and Evaporation Plant; unpublished pamphlet, Canadian Salt Company Limited, 4 p.

Canadian Salt Company Limited

1979: Unpublished mine plan 830 foot level, Pugwash Mine, Cumberland County, Nova Scotia; Nova Scotia Department of Mines and Energy, Halifax.

Carpenter, T. H.

1975: Hants County drilling project; Gulf Minerals Canada Limited; Nova Scotia Department of Mines, Assessment Report 11E/04C 27-I-52(02).

Chambers, A. R.

1924: The salt deposits of Malagash, Nova Scotia; Transactions, Canadian Institute of Mining and Metallurgy, v. 27, p. 248-258.

Chan, A. K.

1974: Stewiacke project, Nova Scotia, summary report 1974 drill program; Nova Scotia Department of Mines, Assessment Report 11E/03C 58-D-43(02).

Chevron Standard Limited

1978: Report of the Bras d'Or area Inverness County; Nova Scotia Department of Mines and Energy, Assessment Report 11F/15B 07-J-71(02).

1981a: Final report on geophysical survey of the Malagawatch area; Nova Scotia Department of Mines and Energy, Assessment Report 11F/15B 40-J-36(01).

1981b: Final report on the seismic survey of the Bras d'Or Lake; Nova Scotia Department of Mines and Energy, Assessment Report 11F/15B 40-0-66(01).

Clifton, H. E.

1967: Solution-collapse and cavity filling in the Windsor Group, Nova Scotia; Geological Society of America Bulletin, v. 78, p. 819-832.

Cole, L. H.

1926: Malagash, salt deposit, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 42-E-19(01).

1930a: Potash salts in the Maritime Provinces of Canada; in Investigations of Mineral Resources and the Mining Industry, 1928; Department of Mines, Canada, Mines Branch, Publication No. 710, p. 19-27.

1930b: The salt industry of Canada, salt occurrences in the Maritime Provinces; Department of Mines, Canada, Mines Branch, Publication No. 716, p. 2-19.

Cole, L. H.
1961: Report on drilling for evaporites in the Sydney Forks area of Cape Breton, Nova Scotia, Canada; Morton Salt Company; Nova Scotia Department of Mines and Energy, Assessment Report 11K/01 40-C-90(01).

Collins, G. A.
1962: Arichat map area, Richmond-Inverness Counties, Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 01*, 21 p.

Cominco Limited
1981: Review and interpretation of existing aeromagnetic and gravity data and a report on ground gravity survey by Allan Spector and Associates Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11E/04B 40-I-17(01).

Cook, H. B. S.
1973: Outline of the geology of Nova Scotia; Department of Geology, Dalhousie University, Halifax, Nova Scotia.

Copeland, M. J.
1959: Coalfields, west half Cumberland County, Nova Scotia; Geological Survey of Canada, Memoir 298, 89 p.

Cote, P. R.
1958: Structure and stratigraphic test hole drilling in the Mabou-Lake Ainslie area, Cape Breton, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(05,06).

1959: Additional geological observations in the Port Hood-Broad Cove area 1959; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(08).

Cote, P. R. and Hill, J. V.
1960: Petroleum, exploration work, maps, DDH records Inverness County, Nova Scotia; Imperial Oil Limited Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(07).

Crosby, D. G.
1962: Wolfville map area (21H) Nova Scotia; Geological Survey of Canada, Memoir 325, 67 p.

Crosby, K. S.
1975a: Final report, diamond-drilling of Salt Springs #1; New Brunswick Department of Natural Resources, Mineral Resources Branch, Topical Report 75-2.

Crosby, K. S.
1975b: Bromine and strontium distributions in the salt deposits of southeastern New Brunswick; New Brunswick Department Natural Resources, Mineral Resources Branch, Topical Report 75-18.

Crowell, G. D.
1971: The Kaiser Celestite operation at Loch Lomond; Canadian Institute of Mining and Metallurgy Bulletin, v. 74, p. 48-52.

Cunningham C.
1969: Report on diamond-drilling, Summerville Group, Hants County, Nova Scotia; New Jersey Zinc Exploration Company (Canada) Limited; Nova Scotia Department of Mines and Energy, Assessment Report 21H/01A 07-I-40(02).

Currie, K. L.
1977: A note on post-Mississippian thrust faulting in northwestern Cape Breton Island; Canadian Journal of Earth Sciences, v. 14, p. 2937-2941.

Dawson, J. W.
1868: Acadian Geology, the Geological Structure, Organic Remains and Mineral Resources of Nova Scotia, New Brunswick and Prince Edward Island, 2nd edition; MacMillan and Company, London.

Dekker, L.
1982a: Chevron's Malagawatch potash exploration program; presented paper, 95th Annual Meeting of the Mining Society of Nova Scotia, Ingonish, Nova Scotia.

1982b: The Malagawatch potash exploration program, Cape Breton, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/15B 40-J-36.

Dew Mining Corporation Limited
1967: Diamond-drill hole log, CIL-1 (NSDM 4508); Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-D-3(02).

Domtar Limited
1967: Gravity map and report; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14D 42-J-59(01).

1968a: Miscellaneous diamond-drill logs, Kingsville, Inverness County; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14D 42-J-80(01).

Domtar Limited
1968b: Miscellaneous diamond-drill logs, St. Peters and Seaview; Richmond County; Nova Scotia Department of Mines and Energy, Assessment Report 11F/10C 42-0-21(02,03).

Donald, J. T. and Company Limited
1938: Certificate of analysis for Malagash Salt Company Limited· Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 42-E-19(00).

Donohoe, H. V.
1976: The Cobequid Mountains Project; in Mineral Resources Division, Report of Activities, 1975; Nova Scotia Department of Mines, Report 76-2, p. 113-124.

Donohoe, H. V. and Wallace, P. I.
1978: Geology of the Cobequid Highlands, preliminary map, scale 1:125 000; Nova Scotia Department of Mines, Map 78-1.

Dow Chemical of Canada Limited
1970: Diamond-drill hole logs DCPR-4 to DCPR-10; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(05).

1972: 1972 Program, Port Malcolm No. 1; Report by Dow Chemical Company; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(06).

1973: Geological report, DCPR-11, Port Richmond; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(10).

1975: A prognosis of the engineering design for the drilling and development of a storage cavity DCPR-12P, including measures to protect the environment; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(15).

Ellsworth, H. V.
1926: Chemistry of the potash-bearing horizon of the Malagash salt deposit, Nova Scotia; Geological Survey of Canada, Summary Report, Part C, 1924, p. 181-198.

Evans, R.
1967: The structure of the Mississippian evaporite deposit at Pugwash, Cumberland County, Nova Scotia; Economic Geology, v. 62, p. 262-273.

1970a: Sedimentation of the Mississippian evaporites of the Maritimes: an alternative model; Canadian Journal of Earth Sciences, v. 7, p. 1349-1352.

Evans R.
1970b: Evaporites in the Mississippian of the Maritime Provinces of Canada; Compte Rendu, Sixième Congress International Stratigraphic Geologique Carbonifère, Sheffield 1967, v. 2, p. 725-736.

Evans, R.
1970c: Genesis of sylvite and carnallite bearing rocks from Wallace, Nova Scotia; in Third International Symposium on Salt, Volume One; Northern Ohio Geological Society Incorporated, Cleveland, Ohio, p. 239-245.

1972: Studies in the evaporites of the Maritime Provinces of Canada; unpublished Ph.D. thesis, University of Kansas, Lawrence, Kansas; Nova Scotia Department of Mines and Energy, Thesis 103.

1974: Geometry and development of structures within the Pugwash diapir, Nova Scotia; in Fourth International Symposium on Salt; Northern Ohio Geological Society, Incorporated, p. 251.

Faribault, E. R. and Fletcher, H.
1893: Antigonish area map sheet; Nova Scotia Old Series Maps, nos. 31, 32, 34 and 35.

1902: Westville sheet; Nova Scotia Old Series Maps, no. 47.

1905: Pugwash sheet; Nova Scotia Old Series Maps, no. 61.

1909: Windsor sheet; Nova Scotia Old Series Maps, no. 73.

Farries Engineering Limited
1976: Drilling and completion report, Bradar Anschutz Hole No. 1 (South Side Harbour), Nova Scotia; Nova Scotia Department of Mines and Energy, Petroleum File 11F/12C/S.

Felderhof, G. W.
1978: Barite, celestite and fluorite in Nova Scotia; Nova Scotia Department of Mines, Bulletin No. 4, 463 p.

Ferguson, S. A.
1946: Strait of Canso map area, Inverness, Richmond, Guysborough and Antigonish Counties, Nova Scotia; Geological Survey of Canada, Paper 46-12.

Ferguson, S. A. and Weeks, L. J.
1950: Mulgrave, Nova Scotia; Geological Survey of Canada, Map 995A.

Fletcher, H.

1887: Annual Report 1886; Geological and Natural History Survey of Canada; v. 2, sec. P, p. 124.

1892: Report on geological surveys and explorations in the Counties of Pictou and Colchester, Nova Scotia; Canada Geological Survey, Annual Report, v. 5, pt. P, 193 p.

Forgeron, S.

1977: The Kaiser Celestite mining operation and mineral potential of the Loch Lomond Basin, Cape Breton, Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 328.

Freeman, G. W.

1972: Stratigraphy of the Cheverie Formation, Minas Basin, Nova Scotia; unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia, Nova Scotia Department of Mines and Energy, Thesis 112, 209 p.

Fundy Geoservices Limited

1978: The Ashfield potash prospect, Cape Breton, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14D 40-J-77(02).

1980: Review of data on the Ashfield potash prospect, Inverness County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14D 40-J-77(03).

Galeski, R. B.

1971: Gravity interpretations, Port Hawkesbury area, Nova Scotia; Report by Airborne Geophysical Surveys Limited for Murphy Oil Company Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11A,B,C,D 42-J-50(01).

Garland, G. D.

1955: Gravity measurements over the Cumberland Basin, Nova Scotia; Canadian Mining and Metallurgical Transactions, v. 43, p. 90-98.

Geldsetzer, H. H. J.

1977: The Windsor Group of Cape Breton Island, Nova Scotia; in Report of Activities, Part A; Geological Survey of Canada, Paper 77-1A, p. 425-428.

1978: The Windsor Group in Atlantic Canada, an update; in Report of Activities, Part C; Geological Survey of Canada, Paper 78-1C, p. 43-48.

Geldsetzer, H. H. J., Giles, P. S., Moore, R. and Palmer, W.

1980: Stratigraphy, sedimentology and mineralization of the Carboniferous Windsor Group, Nova Scotia; Geological Association of Canada-Mineralogical Association of Canada, Halifax, Nova Scotia; Field Trip Guidebook, 42 p.

Gesner, A.

1849: Industrial resources of Nova Scotia; Halifax, Nova Scotia, p. 264-265.

Gilbert, J. F.

1976: Overview of the Dow Chemical of Canada Limited, Cape Breton Island Project; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(06).

Giles, P. S.

1977: The Carboniferous basin study; in Mineral Resources Division, Report of Activities, 1976; Nova Scotia Department of Mines, Report 77-1, p. 115-123.

1978: Time and stratigraphy in the Windsor Group of Nova Scotia; Abstract, Geological Association of Canada, Mineralogical Association of Canada and Geological Society of America Joint Meeting, Toronto, Ontario.

1980: A rugose coral from the E_1 limestone in the Pomquet River section, Antigonish County and the implications for Windsor Group stratigraphy; in Mineral Resources Division, Report of Activities, 1979; Nova Scotia Department of Mines and Energy, Report 80-1, p. 187-194.

1981a: The Windsor Group in the McIntyre Lake area of Cape Breton Island; in Mineral Resources Division, Report of Activities, 1980; Nova Scotia Department of Mines and Energy, Report 81-1, p. 131-139.

1981b: The Windsor Group of the Mahone Bay area, Nova Scotia; Nova Scotia Department of Mines and Energy, Paper 81-3, 51 p.

1981c: Major transgressive-regressive cycles in Middle to Late Viséan rocks of Nova Scotia; Nova Scotia Department of Mines and Energy, Paper 81-2, 27 p.

1982: Geological map of the Eureka area, central Nova Scotia; Nova Scotia Department of Mines and Energy, Map 82-3, scale 1:50 000.

Giles, P. S. and Boehner, R. C.
1979: The Windsor Group stratigraphy in the Shubenacadie and Musquodoboit Basins of central Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 410.

1982a: Geological map of the Shubenacadie and Musquodoboit Basins, central Nova Scotia; Nova Scotia Department of Mines and Energy, Map 82-4, scale 1:50 000.

1982b: Subdivision and regional correlation of strata of the Upper Windsor Group, Cape Breton Island and central Nova Scotia; in Mineral Resources Division, Report of Activities, 1981; Nova Scotia Department of Mines and Energy, Report 82-1, p. 69-78.

Giles, P. S., Boehner, R. C. and Ryan, R. J.
1979: Carbonate banks of the Gays River Formation in central Nova Scotia; Nova Scotia Department of Mines, Paper 79-6, 57 p.

Giles, P. S. and Ryan, R. J.
1976: A preliminary report on the stratigraphy of the Windsor Group in the eastern Minas Sub-basin, Nova Scotia; in Mineral Resources Division, Report of Activities, 1975; Nova Scotia Department of Mines, Report 76-2, p. 100-105.

Gillis, J. W.
1964: Geology of northwestern Pictou County, Nova Scotia; unpublished Ph.D. thesis and map, Pennsylvania State University, University Park, Pennsylvania; Nova Scotia Department of Mines and Energy, Thesis 124.

Goldthwait, J. W.
1924: Physiography of Nova Scotia; Geological Survey of Canada, Memoir 140, 179 p.

Goodman, N. R.
1952: Gypsum and anhydrite in Nova Scotia; Nova Scotia Department of Mines, Memoir No. 1, 75 p.

Goodman, N. R. and Pendle, Y. S.
1955: An investigation into the polyhalite possibilities of the Windsor Formation in Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 019.

Goudge, M. F.
1967: Nova Scotia potash, a survey of the economic possibilities of the deposits; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-19.

Goudge, M. G.
1943: Memo, drilling at Nappan; Nova Scotia Department of Mines and Energy, Assessment Report 21H/16A 42-E-21(00).

Grace, K. A.
1966: Copper, Antigonish County, report on Antigonish Basin, diamond-drill hole and map; Kennco Explorations Canada Limited, Nova Scotia Department of Mines and Energy, Assessment Report 11F/12B 13-B-03(01).

Gregory, D. J.
1974: Boreholes containing salt in Nova Scotia; Nova Scotia Department of Mines, Open File Report 241.

1977: Index to mineral assessment reports; Nova Scota Department of Mines, Report 77-2, 380 p.

1978: Index to Open File Reports; Nova Scotia Department of Mines, Report 78-3, 42 p.

Gulf Oil Canada Limited
1975: Gulf et al. Hastings No. 1, Nova Scotia, well history report; Nova Scotia Department of Mines and Energy, Petroleum File.

Gussow, W. C.
1953: Carboniferous stratigraphy and structural geology of New Brunswick, Canada; Bulletin, American Association of Petroleum Geology, v. 37, no. 7, p. 1713-1816.

Haenggi, W. T.
1973: Geological report, DCPR-11p, Cape Breton, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(09).

Halbouty, M. T.
1967: Salt Domes, Gulf Region, United States and Mexico; Gulf Publishing Company, Houston, Texas, 425 p.

Hale, J. D.
1972: NCO Canso Strat No. 1, Point Tupper - Port Hawkesbury - McIntyre Lake area, Inverness County, Cape Breton Island, Nova Scotia, Canada; report to Northern Canadian Oils Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C 42-J-68(01).

Hale, J. D.
1974: Murphy NCO Canso Strat No. 2, Point Tupper - Port Hawkesbury-McIntyre Lake area, Inverness County, Cape Breton Island, Nova Scotia, Canada; Report to Murphy Oil Company Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C,B 42-J-68(02).

Haliburton, T. C.
1829: History of Nova Scotia; v. 2, Joseph Howe, Halifax, 453 p.

Hamilton, J. B.
1961: Salt in New Brunswick; Mines Branch, Department of Lands and Mines, New Brunswick, Mineral Resources, Report No. 1, 73 p.

Haworth, R. T.
1974: Gravity (Bouguer anomaly) map, Bay of Fundy to Gulf of St. Lawrence; Canadian Hydrographic Service, Department of the Environment, Map 801-D, scale 1:1 000 000.

Hayes, A. O.
1920: The Malagash salt deposit, Cumberland County, Nova Scotia; Geological Survey of Canada, Memoir 121, 24 p.

1931: Report on the potash possibilities of Nova Scotia; in Annual Report on the Mines, 1930, Part 2; Nova Scotia Department of Mines, 147 p.

Hayes, A. O. and Bell, W. A.
1923: The southern part of the Sydney coalfield, Nova Scotia; Geological Survey of Canada, Memoir 133, 108 p.

Heiland Exploration Company
1942: Seismograph survey of southwest Mabou area, Cape Breton Island, Nova Scotia; unpublished map for Cape Breton Petroleum Company.

Hill, J. V.
1959: Preliminary investigation of Windsor carbonates in the Mabou-Port Hood area, 1959; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(07).

Holleman, M.
1976: The nature, origin and distribution of chloride in the Lower B subzone evaporites of Little Narrows, Victoria County, Nova Scotia; unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia; Nova Scotia Department of Mines and Energy, Thesis #472, 153p.

Home Oil Canada Limited
1977a: Report on seismic survey, McIntyre Lake, Inverness County by K. B. S. Burke; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C 42-J-68(05).

1977b: Report on ground gravity survey by Kenting Exploration Services Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C 42-J-68(06).

1978: Report on drilling and compilation of geological and gravity data; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C 42-J-68(07).

How, H.
1869: The Mineralogy of Nova Scotia; Charles Annand, Halifax, p. 127-148.

Howells, K.
1972: An interpretation of the Bay of Inhabitants gravity low; Report to Dow Chemical of Canada Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(07).

Howells, K., Zwicker, D.P. and Bidgood, D. E. T.
1974: Gravity measurements over some salt structures in south Cape Breton Island and in the vicinity of Antigonish, Nova Scotia, Canada; Abstract in Fourth International Symposium on Salt, Northern Ohio Geological Society Incorporated, p. 249.

Howie, R. D.
1966: Catalogue of well samples from Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland at the Geological Survey of Canada, Ottawa; Geological Survey of Canada, Paper 65-40.

1976: Late Paleozoic evaporite deposits of the Atlantic Provinces and adjacent offshore; unpublished Geological Survey of Canada Report; Nova Scotia Department of Mines and Energy, Open File Report 564.

1979: Carboniferous evaporites in Atlantic Canada; Abstract in Abstracts of Papers, Compte Rendu Ninth International Congress of Carboniferous Stratigraphy and Geology, Urbana, Illinois, p. 93-94.

Howie, R. D. and Barss, M. S.
1975: Upper Paleozoic rocks of the Atlantic Provinces, Gulf of St. Lawrence, and adjacent continental shelf; in Offshore Geology of Eastern Canada; Geological Survey of Canada, Paper 74-30, p. 35-50.

Howie, R. D. and Cumming, L. M.
1963: Basement features of the Canadian Appalachians; Geological Survey of Canada, Bulletin 89, 18 p.

Hubel, J. H.
1941: Memorandum on recovery of potash from Malagash salt; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-19(00).

Huffman, A. D.
1968: History and significance of salt in Canada; Canadian Institute of Mining and Metallurgical Bulletin, p. 652-660.

Hurlbut, C. S., Jr.
1971: Dana's Manual of Mineralogy, 18th edition; Wiley, New York, p. 308-309.

Hycarb Engineering Limited
1975: Evaluation of Nova Scotia salt jug terminal, for Stillings Petroleum (Canada) Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C 42-J-68 (04).

Imperial Oil Limited
1931: Development work in Nova Scotia, 1931; in Annual Report on Mines, 1930; Nova Scotia Department of Mines, p. 45-91.

1932: Report on petroleum possibilities of Cumberland and Pictou Counties, Nova Scotia; in Annual Report on Mines, 1931, Part 2; Nova Scotia Department of Mines, p. 2-24.

Johnson, W. A.
1932: Borings in Ontario, Quebec, and the Maritime Provinces; in Summary Report, 1931, Part D; Geological Survey of Canada, p. 42-52.

Johnston, D.
1972: Sylvan Glen property (Logan Option), Antigonish County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09D 13-B-26(01).

Jones, B. E. and Covert, T. G. N.
1972: Geology of the Middle River and Baddeck Forks map areas, Victoria County, Nova Scotia; Nova Scotia Department of Mines, Miscellaneous Publication, 124 p.

Jowett, E. C.
1974: St. Joseph Explorations Limited Progress Report, Dillman option blocks B_1, B_2 and B_3, Imperial Oil Limited option property, Meadowvale - Pembroke property, Upper Stewiacke, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/03D 27-D-48(01).

Kawase, Y.
1967: Report on Scurry - Rainbow Oil Limited sulphur project in the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/04D 60-I-17(02).

Kelley, D. G.
1960: Saint Anns, Nova Scotia; Geological Survey of Canada, Map 38-1960.

1967a: Some aspects of Carboniferous stratigraphy and depositional history in the Atlantic Provinces; in Collected Papers on Geology of the Atlantic Region; Geological Association of Canada, Special Paper 4, p. 213-228.

1967b: Baddeck and Whycocomagh map areas with emphasis on Mississippian stratigraphy of central Cape Breton Island, Nova Scotia (11K/02 and 11F/14); Geological Survey of Canada, Memoir 351.

Kelley, D. G. and MacKasey, W. O.
1965: Basal Mississippian volcanic rocks in Cape Breton Island, Nova Scotia; Geological Survey of Canada, Paper 64-34, 10 p.

Keppie, J. D.
1976: Interpretation of P.P.I. Radar Imagery of Nova Scotia; Nova Scotia Department of Mines, Paper 76-3, 31 p.

1977: Tectonics of southern Nova Scotia; Nova Scotia Department of Mines, Paper 77-1, 34 p.

1982a: The Minas Geofracture; in Major Structural Zones and Faults of the Northern Appalachians, eds. P. St. Julien and J. Béland; Geological Association of Canada, Special Paper 24, p. 263-280.

1982b: Tectonic map of the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, scale 1:500 000.

Keppie, J. D., Giles, P. S. and Boehner, R. C.
1978: Some Middle Devonian to Lower Carboniferous rocks of Cape George, Nova Scotia; Nova Scotia Department of Mines, Paper 78-4, 37 p.

Keppie, J. D. and Smith, P. S.
1978: Age of igneous rocks along the Lennox Passage - St. Peters Lineament, southern Cape Breton Island, Nova Scotia; Nova Scotia Department of Mines, Paper 78-2, 10 p.

Keys, D. A.
1940: Salt, Malagash, Cumberland County, Nova Scotia; miscellaneous memos, mine plans and reports, 1926-1941; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-E-19(00).

Kingston, P. W. and Dickie, D. E.
1979: Geology of New Brunswick potash deposits; Canadian Institute of Mining and Metallurgy Bulletin, v. 72, no. 802, p. 134-141.

Knapp, T. S.
1959: Oil and gas possibilities of MacInnis Brothers' "Ohio Prospect", Antigonish County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09A 39-B-23(01).

Koyden, E. A.
1945: Drill log, Anthony No. 1 and No. 2, for Nova Scotia Oil and Gas Company, Halifax, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/04D 39-I-17(01).

1958: Drill log Anthony No. 3; in Possibilities for Occurrence of Petroleum Reservoirs in Nova Scotia; Nova Scotia Department of Mines and Energy, miscellaneous publication.

Lahupe, D. B.
1967: Diamond-drill log, IP#1, Magnet Cove Barium Corporation, (Dresser Industries Incorporated); Nova Scotia Department of Mines and Energy, Assessment Report 21H/01D 06-I-51(42).

1969: Diamond-drill logs EMCO#1, EMCO#2, and WR-1; Magnet Cove Barium Corporation (Dresser Industries Incorporated); Nova Scotia Department of Mines and Energy, Assessment Report 21H/01D 06-I-51(42).

Lefond, S. J. and Jacoby, C. H.
1975: Salt; in Industrial Minerals and Rocks; American Institute Mining, Metal and Petroleum Engineering Incorporated, p. 995-1042.

Leslie, J. A.
1967: Gravity survey, Upper Kennetcook claim group, Upper Kennetcook, Hants County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/04D 60-I-17(01).

Logan, W. E.
1845: Section of Nova Scotia coal measures as developed at Joggins on the Bay of Fundy; in Report of Progress, Geological Survey of Canada, p. 92-159.

MacDonald, D. R.
1973: Geological wellsite report, Wallace Station No. 1, Nova Scotia, Canada; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 39-E-47(01).

MacDougall, I. and Polley, D. E.
1980: Drilling Logs of Government Core Drills, 1979; Nova Scotia Department of Mines and Energy, Report 80-3, p. 27-28.

MacEachern, S. B.
1959: Well log report, Imperial Mabou #1; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(07).

1960: Well log report, Imperial Port Hood #1; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(07).

MacLaren, A. S.
1956a: Ingonish, Victoria County, Nova Scotia; Geological Survey of Canada, Paper 55-35.

1956b: Cheticamp River, Inverness and Victoria Counties, Nova Scotia; Geological Survey of Canada, Paper 55-36.

MacNabb, B. C., Fowler, J. H. and Covert, T.G.N.
1976: Geology, geochemistry and mineral occurrences of the Northeast Margaree River drainage basin in parts of Inverness and Victoria Counties, Nova Scotia; Nova Scotia Department of Mines, Paper 76-4.

MacNeil, D. J.
1944a: Progress report regarding geological investigations on leases held by the Lion Oil Refining Company, Eldorado, Arkansas; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03B 39-J-35(05).

1944b: Logs of the Lion Oil Refining Company's Mary No. 1 and Mac No. 1, drilled at Southwest Mabou, Inverness County; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03B 39-J-35(08).

1944c: Geological report on the Port Hood Island area, Inverness County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11K/04A 39-J-26(01).

MacNeil, D. J.

1945a: Report on investigations into the oil possibilities of Inverness County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03B 39-J-00(03).

1945b: Revised geological report on the Port Hood Island area, Inverness County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11K/04A 39-J-26(02).

1946: Report on geological surveys in Antigonish and Pictou Counties, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12W 39-B-00(03).

1947: Gas and petroleum possibilities of the Antigonish area, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12W 39-B-04(01).

1952: Geological report on oil and gas possibilities of the Antigonish area; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12W 39-B-04(02).

1955: A report on the petroleum possibilities of the Antigonish area, Nova Scotia; prepared for Eastern-Northern Explorations Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12C 39-B-05(03).

1959: The geology of an area near Antigonish, Nova Scotia and a report on the drilling program sponsored by Lura Corporation Limited within that area; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12C 39-B-05(06).

MacQuarrie, J. R.

1975: Malagash salt, a compilation; North Cumberland Historical Society, Publication No. 5, 61 p.

Magnet Cove Barium Corporation (Division of Dresser Industries Incorporated)

1967: Drill log IP#1; Nova Scotia Department of Mines and Energy, Assessment Report 21H/01D 06-I-51(10).

1969a: Drill log WR-1; Nova Scotia Department of Mines and Energy, Assessment Report 21H/01D 06-I-51(10).

1969b: Drill logs EMCO #1 and #2; Nova Scotia Department of Mines and Energy, Assessment Report 21H/01D 06-I-51(10).

Malagash Salt Company Limited

1953: Borehole logs No. 41 and No. 42; Nova Scotia Department of Mines and Energy, Assessment Report 11E/12C 42-E-47(00).

Martinez, J. D.

1974: Tectonic behavior of evaporites; in Fourth International Symposium on Salt; Northern Ohio Geological Society Incorporated, p. 155-168.

1977: Development of plans for utilization of salt deposits of the Province of Nova Scotia; unpublished report to Nova Scotia Department of Mines, 12 p.

1978: Salt dome caprock- a record of geologic process; in Fifth International Symposium on Salt; Northern Ohio Geological Society Incorporated, v. 1, p. 143-151.

Martinez, J. D. and Thoms, R. L. (editors)

1977: Salt dome utilization and environmental considerations; Proceedings of a symposium held at Louisiana State University; Baton Rouge, Louisiana, 423 p.

Mather, K. F. and Trask, P. D.

1929: Preliminary report on geology and oil exploration in Cape Breton Island, Nova Scotia; in Annual Report on the Mines, 1928; Nova Scotia Department of Mines, p. 260-301.

McCutcheon, S. R.

1981: Stratigraphy and paleogeography of the Windsor Group in southern New Brunswick; New Brunswick Department of Natural Resources, Geological Surveys Branch, Open File Report 81-31, 210 p.

McLeod, C.

1966: Diamond-drill log, NJZ1-S-66; Nova Scotia Department of Mines and Energy, Assessment Report 21H/01A 07-I-40(01).

Messervey J. P.

1930: Memo on Malagash drilling; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-19(00).

1942: Memo, Amherst drilling project; Nova Scotia Department of Mines, and Energy, Assessment Report 21H/16A 42-E-01(00).

1943: Memo, Amherst diamond-drilling project, NSDM Record #961; Nova Scotia Department of Mines and Energy, Assessment Report 21H/16A 41-E-21(00).

Messervey, J. P.
1950: Salt and potash in Nova Scotia; Nova Scotia Department of Mines and Energy, pamphlet, 14 p.

Miller, A. H.
1934: Gravimetric survey of the Malagash salt deposit; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 42-E-19(02).

Miller, A. H. and Norman, G. W. H.
1936: Gravimetric survey of the Malagash salt deposit, Nova Scotia; American Institute of Mining and Metallurgical Engineers, Technical Publication 737, p. 2-11.

Milligan, G. C.
1970: Geology of the George River series, Cape Breton, stratigraphy, structure and economic geology; Nova Scotia Department of Mines, Memoir 7, 111 p.

Millmor-Rogers Syndicate
1974: Miscellaneous drill logs and map, James River area; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09A 40-B-14(01).

Moore, R. G.
1967: Lithostratigraphic units in the upper part of the Windsor Group, Minas Sub Basin, Nova Scotia; in Collected Papers on the Geology of the Atlantic Provinces; Geological Association of Canada, Special Paper No. 4, p. 245-266.

Moore, R. G. and Austin, I. A.
1979: The Herbert River and Musquodoboit Limestone Members, keys to the reconstruction of the Fundy depositional trough in the Upper Windsor, Late Mississippian times in the Atlantic area of Canada; Abstract in Abstracts of Papers, Ninth International Congress of Carboniferous Stratigraphy and Geology, Urbana, Illinois.

Moore, R. G. and Ryan, R. J.
1976: Guide to the invertebrate fauna of the Windsor Group in Atlantic Canada; Nova Scotia Department of Mines, Paper 76-5, 57 p.

Murphy, J. B, Keppie, J. D. and Hynes, A.
1980: Geology of the northern Antigonish Highlands; in Mineral Resources Division, Report of Activities, 1979; Nova Scotia Department of Mines and Energy, Report 80-1, p. 103-108.

Murphy Oil Company Limited and Northern Canadian Oils Limited
1973: Proposed salt cavern storage at MacIntyre Lake, Richmond and Inverness Counties, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11C 42-J-68 (03).

Murray, B. C.
1960: Stratigraphy of the Horton Group in parts of Nova Scotia; Nova Scotia Research Foundation Publication.

Murray, D. A.
1971: Petrology and paleoecology of the Williams Point Limestone, Antigonish County, Nova Scotia; unpublished M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia; Nova Scotia Department of Mines and Energy, Thesis 270, 109p.

1975: Limestones and dolomites of Nova Scotia; Nova Scotia Department of Mines, Bulletin No. 2, Pt. 2, 155 p.

Nance, R. D.
1978: Petrology of salt core, Rayburns Dome; in An Investigation of the Utility of Gulf Coast Domes for the Storage or Disposal of Radioactive Wastes; Institute for Environmental Studies, Louisiana State University, Baton Rouge, Louisiana, v. 2, p. 67-78.

Neale, E. R. W.
1963a: Pleasant Bay, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Geological Map 1119A.

1963b: Dingwall, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Geological Map 1124A.

1964a: Cape St. Lawrence, Nova Scotia; Geological Survey of Canada, Geological Map 1149A.

1964b: Cape North, Nova Scotia; Geological Survey of Canada, Geological Map 1150A.

Neves, R. and Belt, E. S.
1970: Some observations on Namurian and Viséan spores from Nova Scotia, Britain and Northern Spain; Sixième Congrès International de Stratigraphie et de Geologie du Carbonifère, Sheffield, 1967, Compte Rendu, v. III, p. 1233-1242.

New Brunswick Department of Natural Resources

1971: Request for submissions for the exploration of a salt-potash prospect, Sussex area, Kings County, New Brunswick; New Brunswick Department of Natural Resources, Mineral Resources Branch.

1975: Request for submissions for the exploration and possible development of a salt-potash prospect, Salt Springs area, Kings County, New Brunswick; New Brunswick Department of Natural Resources, Mineral Resources Branch.

Noranda Exploration Company Limited

1977: Report of work, Special License 1-77, St. Particks Channel - Glendale property; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14D 40-J-59(04).

1978: Report on (Ashfield) gravity, magnetometer and aeromagnetic survey interpretations; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14D 40-J-77(02).

1979: Report of work, Special License 1-78, Ashfield, Inverness County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/14A 40-J-77 (01).

1981: Report of work, Special License 3-80, Bras d'Or Lake region, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11D 40-0-27(01).

Norman, G. W. H.

1932a: Oil prospects of Lake Ainslie area, Cape Breton; Geological Survey of Canada, Economic Geology Series No. 9, p. 182-187.

1932b: Salt deposits of Nova Scotia and New Brunswick; in Summary Report, 1931, Part D; Geological Survey of Canada, p. 28-33

1935: Lake Ainslie map area, Nova Scotia; Geological Survey of Canada, Memoir 177, 103 p.

Norman, G. W. H. and Bell, W. A.

1938: Oxford sheet (west half), Cumberland and Colchester Counties, Nova Scotia; Geological Survey of Canada, Map 410A.

Nova Scotia Department of Mines

1919: Drill report 378; in Annual Report on the Mines, 1918; Nova Scotia Department of Mines, p. 57-58.

Nova Scotia Department of Mines

1920: Drill report 385-387; in Annual Report on the Mines, 1919; Nova Scotia Department of Mines, p. 55-57.

1923: Drill logs and report 588-590; in Annual Report on the Mines, 1924; Nova Scotia Department of Mines, p. 233-234.

1925: Drill logs and report 474-476; in Annual Report on the Mines, 1924; Nova Scotia Department of Mines, p. 233-234.

1926: Drill logs and report 477-478, in Annual Report on the Mines, 1925; Nova Scotia Department of Mines, p. 235.

1927: Drill logs and report 492-500; in Annual Report on the Mines, 1926; Nova Scotia Department of Mines, p. 139-146.

1928: Drill logs and report 519-523; in Annual Report on the Mines, 1927; Nova Scotia Department of Mines, p. 160-163.

1929: Drill logs and report 669-679; in Annual Report on the Mines, 1928; Nova Scotia Department of Mines, p. 153-159.

1938: Drill log and report 876; in Annual Report on the Mines, 1937; Nova Scotia Department of Mines, p. 195.

1940: Analysis of chip samples from potash zone in new crosscut 24th level west; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 49-E-19(00).

1941: Drill logs and report 916-930; in Annual Report on the Mines, 1940; Nova Scotia Department of Mines, p. 88-98.

1943: Drill log record 962; Nova Scotia Department of Mines and Energy, Assessment Report 21H/16A 42-E-21(00).

1944: Drill log record 960, 961 and 962; in Annual Report on the Mines, 1943; Nova Scotia Department of Mines, p. 53-56.

1945: Drill log record 962; in Annual Report on the Mines, 1944; Nova Scotia Department of Mines, p. 48.

1947: Drill log record; in Annual Report on the Mines, 1946; Nova Scotia Department of Mines, p. 79.

Nova Scotia Department of Mines

1952a: Report on the results to date of the development of a soda ash industry in Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12C 42-B-05(02).

1952b: Drill log record; in Annual Report on the Mines, 1951; Nova Scotia Department of Mines, p. 55, 65-66.

1953a: Drill log and report 1850, 1851; in Annual Report on the Mines, 1952; Nova Scotia Department of Mines, p. 60-61.

1953b: Drill log records 1835, 1836; in Annual Report on the Mines, 1952; Nova Scotia Department of Mines, p. 55-56.

1954: Drill log 1977 and 1978; in Annual Report on the Mines, 1953; Nova Scotia Department of Mines, p. 80 [illegible].

1957: Drill log of Sunoco No. 1A; log of Lion Oil Company's Mary No. 1 well; drill log of Anthony No. 3; in Annual Report on the Mines, 1956; Nova Scotia Department of Mines, p. 142-172.

1959: Drill logs for Nova Scotia Department of Mines 2554 and 2555; Drilling Logs of Government Core Drills, 1958; Nova Scotia Department of Mines, p. 8.

1960: Annual report on the mines, 1959; Nova Scotia Department of Mines p. 61-62.

1926-69: Potash prospects in the Malagash salt deposit of Malagash, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-19(00).

1963: Drilling Logs of Government Core Drills, 1962; Nova Scotia Department of Mines, p. 16-17.

1966a: Potash, 1966; Nova Scotia Department of Mines and Energy File Report 049.

1966b: Drill log and report 4290 (Malagash No. 1); in Annual Report on the Mines, 1965; Nova Scotia Department of Mines, p. 48-49.

1966c: Drill logs Malagash No. 1 and No. 2; Nova Scotia Department of Mines and Energy, Open File Report 049.

1966d: Drill logs Wallace No. 1 and No. 2; Nova Scotia Department of Mines and Energy, Open File Report 049.

Nova Scotia Department of Mines

1967: Drilling Logs of Government Core Drills, 1966; Nova Scotia Department of Mines, p. 6.

1970: Drilling Logs of Government Core Drills; Nova Scotia Department of Mines, p. 29-30, 43p.

1975: Drill log of HC-1, Clarksville, Hants County, Nova Scotia; unpublished drill log, Nova Scotia Department of Mines and Energy, Halifax.

1976: Geology, minerals and mining in Nova Scotia; Nova Scotia Department of Mines, Information Series No. 1.

1978: A history of coal mining in Nova Scotia; Nova Scotia Department of Mines, Information Series No. 2.

Nova Scotia Department of Mines and Energy

1979: Drill log of E-1(#6922); in Drilling Logs of Government Core Drills, 1978; Nova Scotia Department of Mines and Energy, Report 79-2, p. 31C.

Nova Scotia Research Foundation

1955: Total gravity, Carboniferous Basin, Antigonish area; unpublished map, Nova Scotia Department of Mines and Energy, scale 1" = 1 mile.

1957: Report on geophysical exploration, western Hants County, Nova Scotia, for Magnet Cove Barium Corporation; Nova Scotia Research Foundation Report-57; Nova Scotia Department of Mines and Energy, Open File Report 330.

1959a: Report on geophysical exploration, Cumberland, Colchester and Pictou Counties; Nova Scotia Department of Mines and Energy, Open File Report 054.

1959b: Seismic survey Mabou area, Inverness County; for Imperial Oil Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(07).

1959c: Geophysical exploration Antigonish County, 1952-1959; Lura Corporation, Montreal, Quebec; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12 39-B-05(05).

1962: Preliminary report, potash potential in Nova Scotia; unpublished Nova Scotia Research Foundation Report.

1964: Bouguer gravity anomaly maps 11E/13, 21H/16 and 21H/09; Nova Scotia Research Foundation, scale 2" = 1 mile.

Nova Scotia Research Foundation

1965a: Report on geophysical (gravity) exploration, Port Hawkesbury area, Richmond County, Nova Scotia; for Dow Chemical Company of Canada Limited; Nova Scotia Research Foundation, Report 20-65.

1965b: A quantitative interpretation of the Port Hawkesbury gravity anomaly; Nova Scotia Research Foundation, Report 20A-65 (supplement to report 20-65).

1966a: Gravity survey in Hants, Cumberland and Halifax Counties for Scurry-Rainbow Oil Company; Nova Scotia Research Foundation, Report 7-67.

1966b: Report on the additional gravity exploration, Port Hawkesbury area, Cape Breton; Nova Scotia Research Foundation, Report 8-67.

1967a: Second report on geophysical exploration, Roslin and Wallace areas, Cumberland County; Nova Scotia Research Foundation, Report No. 3-67; Nova Scotia Department of Mines and Energy, Open File Report 049.

1967b: Analysis of drill cores from Wallace #1 and Wallace #2 boreholes; Nova Scotia Department of Mines and Energy, Open File Report 049.

1967c: The quantitative interpretation of the Port Hawkesbury gravity anomaly; Nova Scotia Research Foundation, Report 1-67 (supplement to report 20A-65).

1967d: Bouguer anomaly map and residual anomaly map Lennox Passage; Nova Scotia Department of Mines and Energy, Assessment Report 11F/10C 42-D-21(01).

1968a: Spectrochemical lab report, rock salt cores Wallace #1; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-47(01).

1968b: Spectrochemical lab report, water solution from salt core bags Wallace #2; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-47(01).

1968c: Summary report on Joint Venture, Hilden Beaver Brook, Colchester County; Nova Scotia Department of Mines and Energy, Assessment Report 11E/06B 60-D-26(03).

1968d: Hydrosonde survey, Bay of Inhabitants, Cape Breton; Nova Scotia Research Foundation, Report 3-68.

Nova Scotia Research Foundation

1969: Spectrochemical lab report, rock salts, Wallace #2; Nova Scotia Department of Mines and Energy, Assessment Report 11E/14B 40-E-47(01).

1971: Gravity survey map, Port Hawkesbury, 1971, project 2358; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-J-50(01).

1972: Bouguer anomaly map, River Inhabitants; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-D-30(07).

1974: Some notes on James River Station gravity data; Amax Exploration; Nova Scotia Department of Mines and Energy, Assessment Report 11E/08 42-B-14(01).

1977: Bouguer gravity map 11F/12; Nova Scotia Research Foundation, scale 1:50 000.

Ozshin, S.

1967: Preliminary evaluation of the potash occurrence in Nova Scotia; Saskatchewan Research Council, Engineering Division, Nova Scotia Department of Mines and Energy, Open File Report 049.

Pacific Petroleum Limited

1964: Well history, Pacific Fox Harbour C-96V; Nova Scotia Department of Mines and Energy, Assessment File 11E/13A 39-E-14(01).

Pohly, R. A.

1952a: Report on gravity-magnetic survey, South River area, Nova Scotia; Seismograph Service Corporation, Tulsa; Nova Scotia Department of Mines, Assessment Report 11F/12C 42-B-05(01).

1952b: Exploration in Nova Scotia; Oil and Gas Journal, October 6, 1952, v. 51, no. 22, p. 118-127.

Poole, W. H.

1976: Plate tectonic evolution of the Canadian Appalachian region; in Report of Activities, Part B; Geological Survey of Canada, Paper 76-1B, p. 113-126.

Poole, W. H., Sanford, B. V., Williams, H. and Kelley, D. G.

1970: Geology of southeastern Canada; in Geology and Economic Minerals of Canada; Geological Survey of Canada, Economic Geology Report, No. 1, p. 278-299.

Potter, R. R.
1980: Potash deposits of Atlantic Canada with special reference to New Brunswick; unpublished paper presented at the 93rd Annual Meeting of the Mining Society of Nova Scotia, Ingonish, Nova Scotia, 37 p.

Potter, R. R., Hamilton, J. B. and Worth, J. H.
1972: Progress report, salt-potash prospect, Sussex area, New Brunswick; New Brunswick Department of Natural Resources, Mineral Resources Branch.

Ray, R. H., Incorporated
1944: Gravity meter report, Mabou, Nova Scotia, Cape Breton Island, Canada; Lion Oil Refining Company; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03B 39-J-35(06).

Richter-Bernburg, G.
1972: Saline deposits in Germany; a review and general introduction to the excursions; in Geology of Saline Deposits; Proceedings, Hanover Symposium, 1968, UNESCO, 1972, p. 275-287.

Roliff, W. A.
1932: Imperial Oil Limited, development work in Nova Scotia, 1931; in Annual Report on the Mines, 1931; Nova Scotia, Department of Mines, Pt. 2, p. 43-91.

Roth, J.
1979a: Report on gravity survey, Oxford, Nova Scotia (Amax Potash); Nova Scotia Department of Mines and Energy, Assessment Report 11E/12C 40-E-23(01)

1979b: Report on resistivity surveys, Oxford, Nova Scotia (Amax Potash); Nova Scotia Department of Mines and Energy, Assessment Report 11E/12C 40-E-23(02).

Rowe, R. B.
1967: Dow Chemical Port Richmond No. 1, geological field log; Dow Chemical Company; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(02).

1968a: Geological and analytical data, Dow Chemical Port Richmond No. 2; Dow Chemical Company; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(03).

1968b: Geological and analytical data, Dow Chemical Port Richmond No. 3; Dow Chemical Company; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11B 42-0-30(03).

Ryan, R. J.
1978a: The paleontology and paleoecology of the Gays River Formation in Nova Scotia; unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia; Nova Scotia Department of Mines and Energy, Thesis 314, 148p.

1978b: The paleontology of the Gays River Formation - progress report; in Mineral Resources Division, Report of Activities, 1977; Nova Scotia Department of Mines, Report 78-1, p. 81-82.

Sage, N. M.
1954: The stratigraphy of the Windsor Group in the Antigonish quadrangles and the Mahone Bay-St. Margarets Bay area, Nova Scotia; Nova Scotia Department of Mines, Memoir 3, 168 p.

Salt, W. T.
1970: Gravity survey of the Canso area, Nova Scotia; for Murphy Oil Company Limited by Overland Exploration Services (1969) Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11F/11 42-J-50(01).

Sangster, A. L., Binney W. P. and Jowett, E. C.
1975: Potash exploration on special license 1-75 Shubenacadie and Stewiacke areas, Hants, Colchester Counties, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/03 40-D-12(01).

Schenk, P. E.
1967a: The Macumber Formation of the Maritime Provinces, Canada, a Mississippian analogue to recent strandline carbonates of the Persian Gulf; Journal of Sedimentary Petrology, v. 37, no. 2, p. 365-376.

1967b: The significance of algal stromatolites to paleo-environmental and chronostratigraphic interpretations of the Windsorian Stage (Mississippian) Maritime Provinces; in Collected Papers on Geology of The Atlantic Region; Geological Association of Canada, Special Paper No. 4, p. 229-243.

1969: Carbonate-sulphate-redbed facies and cyclic sedimentation of the Windsorian Stage (Middle Carboniferous), Maritime Provinces; Canadian Journal of Earth Sciences, v. 6, no. 5, p. 1037-1066.

Scurry Rainbow Oil Limited
1967: Report on Scurry - Rainbow Oil Limited sulphur project in the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/04D 60-I-17(02).

Seismograph Service Corporation
1958: Gravity meter survey in the Judique area, Cape Breton Island, Nova Scotia, Canada; Imperial Oil Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(06).

1959: Report on a gravity meter survey conducted in Inverness County, Cape Breton Island, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(08).

Shaw, W. S.
1951: Preliminary map, Springhill, Cumberland and Colchester Counties, Nova Scotia; Geological Survey of Canada, Paper 51-11.

1969: Salt exploration, South Side Harbour, Antigonish, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12C 42-B-25(01).

Shaw, W. S. and Blanchard, J. D.
1968: Salt deposits of the Maritime Provinces of Canada; Abstract in Saline Deposits, ed. R. B. Mattox; Geological Society of America, Special Paper 88, p. 414-415.

Shea, F. S.
1970: Salt basins in Nova Scotia; in Third International Symposium on Salt; The Northern Ohio Geological Society Incorporated, Cleveland, Ohio, v. 1, p. 306-316.

Shea, F. S. and Bingley, J.
1966: Potash project, Cumberland County, Nova Scotia, geological, geophysical, geochemical and DDH reports and maps 11E/NW, 1965-67; Nova Scotia Department of Mines, Nova Scotia Research Foundation and Atlantic Development Board; Nova Scotia Department of Mines and Energy, Open File Report 049.

Shea, F. S. and Wallace, J. D.
1962: Port Hawkesbury Project, geological, geochemical and groundwater investigations of southwestern Inverness and Richmond Counties, Nova Scotia; Nova Scotia Department of Mines, Bulletin No. 1.

Smith, F. G.
1960: Report to Imperial Oil Limited, analysis of rock salt, Imperial Port Hood #1 well; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(10).

Soquip A. C. C. et al.
1975: Well history report Soquip A.C.C., et al., Noel No. 1; Nova Scotia Department of Mines and Energy, Petroleum File 11E/4D/W.

Sounya, F. J.
1975: Stratigraphy and biostratigraphy of Gulf Anschutz Scurry Rainbow Hastings No. 1 well, Nova Scotia; Nova Scotia Department of Mines and Energy, Petroleum File 21H/16A/V.

Sproule, J. C. and Associates Limited
1966a: Well history, Wallace No. 1; Nova Scotia Department of Mines and Energy, Open File Report 049.

1966b: Well history, Wallace No. 2; Nova Scotia Department of Mines and Energy, Open File Report 049.

Stacey, M. C.
1953: Stratigraphy and palaeontology of the Windsor Group (Upper Mississippian) in parts of Cape Breton Island, Nova Scotia; Nova Scotia Department of Mines, Memoir 2, 143 p.

Stevenson, I. M.
1958: Truro map area, Colchester and Hants Counties, Nova Scotia; Geological Survey of Canada, Memoir 297.

1959: Shubenacadie and Kennetcook map areas, Colchester, Hants and Halifax Counties, Nova Scotia; Geological Survey of Canada, Memoir 302.

Stewart, E. B.
1976: Stratigraphy and geochemistry of the "A" subzone, Lower Windsor Group near Antigonish, Nova Scotia; unpublished B.Sc. thesis, Acadia University, Wolfville, Nova Scotia; Nova Scotia Department of Mines and Energy, Thesis 354, 102p.

Stonehouse, D. H.
1979: Salt; in Canadian Minerals Yearbook, 1978; Canada Department of Energy, Mines and Resources, Mineral Report 27, p. 381-388.

Sun Oil Company Limited
1946: Drill logs Sunoco #1 and Sunoco #1A, Minudie Anticline, Nova Scotia, Canada; Nova Scotia Department of Mines and Energy, Assessment Report 21H/16A 39-E-21(02).

Taylor, F. C.
1969: Geology of the Annapolis-St. Mary's Bay map area, Nova Scotia; Geological Survey of Canada, Memoir 358.

Upham, M. A.
1980: The economics and marketing of Canadian potash; Canadian Institute of Mining and Metallurgy Bulletin, v. 73, p. 160-165.

U.S. Borax
1976: Geology report on Lower South River property; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12B,C 07-B-35(01).

Utting, J.
1978: Palynological investigations of the Windsor Group (Mississipian) of Port Hood Island and other localities on Cape Breton Island Nova Scotia; *in* Current Research, Part A; Geological Survey of Canada, Paper 78-1A, p. 205-207.

1980: Palynology of the Windsor Group (Mississippian) in a borehole at Stewiacke, Shubenacadie Basin, Nova Scotia; Canadian Journal of Earth Sciences, v. 17, p. 1031-1045.

van de Poll, H. W.
1972: Stratigraphy and economic geology of Carboniferous basins in the Maritime Provinces; Excursion A60, XXIV International Geological Congress, 1972, Montreal, Quebec, p. 1-16.

Wallace, P. I. and Donohoe, H. V.
1977: The Cobequid Highlands Survey; *in* Mineral Resources Division, Report of Activities, 1976; Nova Scotia Department of Mines, Report 77-1, p. 167-179.

Ward, M. C.
1974: Report on exploration Gael-Sylvan Glen property, Antigonish County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09D 13-B-26(02).

1975a: Drill log and location map SV 74-3; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09D 13-B-26(03).

Ward, M. C.
1975b: Summary report on diamond-drilling Gael potash, Addington Forks area, Antigonish County, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11E/09A 40-B-08(01).

Webb, G. W.
1969: Paleozoic wrench faults in Canadian Appalachians; American Association Petroleum Geologists, Memoir 12, p. 754-786.

Weeks, L. J.
1948: Londonderry and Bass River map areas, Colchester and Hants Counties, Nova Scotia; Geological Survey of Canada, Memoir 245, 86 p.

1954: Southeast Cape Breton Island, Nova Scotia; Geological Survey of Canada, Memoir 277, 112 p.

1955: Grand Narrows, Cape Breton, Richmond, Victoria and Inverness Counties, Cape Breton Island; Geological Survey of Canada, Map 1040A.

1964: St. Peters, Richmond County, Cape Breton Island; Geological Survey of Canada, Map 1083A.

White, R. D.
1972: The Cumberland Basin - a possible rift; Canadian Institute of Mining Transactions, v. 85, p. 267-272.

Whitehead, W. L.
1941: Oil prospects of western Cape Breton Island, Nova Scotia Canada; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(01).

1943: Report on geological surveys in Inverness County, western Cape Breton Island, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11K/03 39-J-00(02).

1944a: Report on geological surveys in Antigonish and Pictou Counties, Nova Scotia; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12W 39-B-00 (01).

1944b: Report on geological surveys in Antigonish and Pictou Counties, Nova Scotia; Pictou Petroleum Company; Nova Scotia Department of Mines and Energy, Assessment Report 11F/12W 39-B-00(02).

Williams,
1914: Arisaig-Antigonish district, Nova Scotia; Geological Survey of Canada, Memoir 60, 173 p.

Wilson, H. S.
1960: Potash possibilities of the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 239.

Worth, J. K.
1972: Final report on diamond-drilling, Sussex area, New Brunswick; New Brunswick Department of Natural Resources, Mineral Development Branch, Topical Report 72-3.

Wright, W. J.
1931: Reports on Cheverie, Windsor and Shubenacadie Basins; in Annual Report on the Mines, 1930, Part 2; Nova Scotia Department of Mines, p. 115-142.

Wright, W. J., Roliff, W. A., Roundy, P. V., Britton, G. C. and Moore, P. D.
1931: Geological map of the Minudie Anticlinourium, Cumberland County, Nova Scotia, and Westmorland County, New Brunswick; unpublished Nova Scotia Department of Mines, Assessment File.

APPENDIX 1

DRILLHOLE DATA
SUMMARY TABLES

HANTS-COLCHESTER AREA

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft.(m)	TOTAL DEPTH OF WELL ft.(m)	ELEVATION* OF WELL ft.(m)	ELEVATION OF TOP OF SALT ft.(m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
FALMOUTH #2	21A/06A	Windsor	Falmouth	bed in anhydrite	11(3)	789(240)	25(8)	-518(-158)	44°59'23"	64°09'57"	105	A	1922	private	chips	fresh water	GSC***
FALMOUTH #4	21A/06A	Windsor	Falmouth	bed in anhydrite	estimated to be 11(3)	estimated to be 789(240)	25(8)	-518(-158)	44°59'24"	64°09'56"	105	A	1922	private	chips	fresh water	unknown
NSDM 4076 (MJZ 2-8-69)	21H/01B	Wolfville	Summerville	thin beds in anhydrite	uncertain	1485(453)	141(43)	———	45°06'11"	64°10'37"	88	P	1969	New Jersey Zinc Corp.	NQ	unknown	NSDME**
IP-1	21H/01D	Wolfville	Walton	bed with anhydrite	155(47)	1705(520)	200(61)	-1350(-411)	45°12'05"	64°01'19"	?	?	1967	Dresser Min.	?	?	unknown
SRS-3	11E/04C	Kennetcook	Stanley	bed with anhydrite	approximately 50(15)	1200(366)	150(45)	-1000(-305)	45°08'04"	63°57'24"	10	M	1966	Scurry Rainbow	chips	mud	NSDME
EMCO#1	11E/04C	Kennetcook	Walton	beds in shale	uncertain	1371(418)	150(45)	-935(-285)	45°12'11"	63°59'30"	61	L	1969	Dresser Min.	B	unknown	lost
EMCO #2	11E/04C	Kennetcook	Walton	beds in shale	uncertain	1195(364)	125(38)	uncertain	45°13'14"	63°54'56"	80	M	1969	Dresser Min.	B	unknown	lost
WR-1	11E/04C	Kennetcook	Walton	beds in shale	uncertain	1998(609)	100(30)	-1030(-314)	45°12'15"	63°51'52"	67	K	1969	Dresser Min.	B	unknown	lost
GM-5	11E/04C	Kennetcook	Upper Walton River	bed with anhydrite	35(11)	943(287)	70(21)	-838(-255)	45°11'15"	63°51'39"	54	G	1975	Gulf Minerals	NQ-BQ	fresh water	NSDME
ANTHONY #3	11E/04D	Kennetcook	Kennetcook	bed with anhydrite	126(38)	2588(789)	175(53)	-1156(-352)	45°10'47"	63°43'52"	37	Q	1955	Nova Scotia Oil and Gas	chips	mud	GSC
MC-1	11E/04B,C	Kennetcook	Clarksville	bed with anhydrite	143(44) and 40(12)	1218(371)	150(45)	-740(-226) and -1028(-313)	45°06'50"	63°49'29"	100	F	1974	IMC	NQ	brine	NSDME
BEAVER BROOK (BD-1)	11E/06B	Truro	Beaver Brook	bed with anhydrite	87(27)	1404(428)	240(73)	-1077(-328)	45°16'51"	63°25'47"	33	F	1968	New Senator-Peel	NQ-BQ	brine	unknown
BEAVER BROOK #2 (NSDM 4735)	11E/06B	Truro	Beaver Brook	bed with anhydrite	114(35) and 472(144)	2398(731)	240(73)	-1046(-319) and -1686(-514)	45°16'50"	63°25'48"	33	F	1968	New Senator-Peel Elder	NQ-BQ	brine	NSDME

*with respect to mean sea level **Nova Scotia Department of Mines and Energy ***Geological Survey of Canada

SHUBENACADIE-STEWIACKE DEPOSIT

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft.(m)	TOTAL DEPTH OF WELL ft.(m)	ELEVATION* OF WELL ft.(m)	ELEVATION OF TOP OF SALT ft.(m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
117-1	11E/03D	Shubenacadie	Shubenacadie-Stewiacke	beds with siltstone and anhydrite	20(6.1)	798(243.2)	120(36.6)	-658(-200.6)	45°14'51"	63°01'30"	90	Q	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
117-6	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		25(7.6)	778(237.1)	85(25.9)	-668(-203.6)	45°14'22"	63°03'32"	99	D	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
116-1	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		153(46.6)	826(251.8)	150(45.7)	-523(-159.4)	45°11'20"	63°00'50"	49	L	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
116-2	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		21(6.4)	758(231)	100(30.5)	-637(-194.2)	45°10'24"	63°02'45"	46	J	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
153-4	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		558(170.1)	1928(587.7)	80(24.4)	-1231(-375.2)	45°12'37"	63°02'48"	75	A	1975	St. Joseph-Noranda	NQ	oil mud	NSDME**
117-4	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		17(5.2)	736(224.3)	150(45.7)	-569(-173.4)	45°14'51"	63°06'40"	102	P	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
117-3	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		58(17.7)	778(237.1)	155(47.2)	-565(-172.2)	45°14'43"	63°06'48"	102	R	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
117-2	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		22(6.7)	708(215.8)	120(36.6)	-562(-171.3)	45°14'35"	63°06'48"	102	G	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
153-3	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		248(75.6) 12(3.7) 30(9.1) 33(10.1) 36(11) 6(1.8) 16(4.9)	2228(679.1)	74(22.6)	-1821(-555) -1749(-533.1) -1498(-456.6) -1351(-411.8) -791(-241.1) -766(-233.5) -654(-199.3)	45°11'36"	63°11'08"	58	O	1975	St. Joseph-Noranda	NQ	oil mud	NSDME

*with respect to mean sea level **Nova Scotia Department of Mines and Energy

SHUBENACADIE-STEWIACKE DEPOSIT (continued)

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTER-SECTION(S) ft. (m)	TOTAL DEPTH OF WELL ft. (m)	ELEVATION* OF WELL ft. (m)	ELEVATION OF TOP OF SALT ft. (m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
SR-1	11E/03C	Shubenacadie	Shubenacadie-Stewiacke	beds with siltstone and anhydrite	12(3.7)	1050(320)	250(76.2)	-788(-240.3)	45°08'47"	63°12'08"	15	E	1973	Aurum	BQ	fresh water	Fundy Gypsum Company
D1-74	11E/03C	Shubenacadie	Shubenacadie-Stewiacke		20(6.1)	727(221.6)	75(22.9)	-632(-192.6)	45°08'31"	63°18'41"	22	D	1974	Denison	BQ	fresh water	Fundy Gypsum Company
D2-74	11E/03C	Shubenacadie	Shubenacadie-Stewiacke		30(9.1)	917(279.5)	100(30.5)	-787(-239.9)	45°07'36"	63°20'45"	44	L	1974	Denison	BQ	fresh water	lost
BB-1	11E/03C	Shubenacadie	Shubenacadie-Stewiacke		893(272.2) 30(9.1) 41(12.5)	2928(892.5)	40(12.2)	-1557(-474.6) -1269(-386.8) -1106(-337.1)	45°09'18"	63°19'14"	28	B	1976	U.S. Borax	NQ-BQ	salt brine	NSDME**
S-4	11E/03C	Shubenacadie	Shubenacadie-Stewiacke		39(11.9)	1207(367.9)	40(12.2)	-1074(-327.4)	45°09'10"	63°19'15"	28	B	1972	Denison	BQ	fresh water	Fundy Gypsum Company
114-4	11E/03C	Shubenacadie	Shubenacadie-Stewiacke		190(57.9)	953(290.5)	83(25.3)	-680 (-207.3)	45°08'56"	63°24'50"	32	Q	1974	St. Joseph	BQ	fresh water	Fundy Gypsum Company
114-3	11E/03C	Shubenacadie	Shubenacadie-		20(6.1)	818(249.3)	48(14.6)	-750(-228.6)	45°09'50"	63°23'54"	17	N	1974	St. Joseph	BQ	fresh water	Fundy Gypsum
153-1	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		1034(315.2) 8.5(2.6)	2237(681.8)	58(17.7)	-935(-285) -649.5(-198)	45°06'28"	63°25'14"	88	J	1975	St. Joseph-Noranda	BQ	oil mud	NSDME
113-3	11E/03D	Shubenacadie	Shubenacadie-Stewiacke		20(6.1)	828(252.4)	83(25.3)	-725(-221)	45°03'26"	63°26'30"	58	A	1975	St. Joseph-Noranda	BQ	fresh water	Fundy Gypsum Company
153-2	11E/04A	Kennetcook	Shubenacadie-Stewiacke		663(202.1)	1757(535.5)	170(51.8)	-747(-227.7)	45°03'14"	63°30'32"	48	P	1975	St. Joseph-Noranda	BQ	oil mud	NSDME
LWMJ-53	11D/13D	Uniacke	Shubenacadie-Stewiacke		30(9.1)	1037(316.1)	43(13.1)	-964(-293.8)	44°59'09"	63°31'52"	98	B	1974	Amax/Imperial Oil	BQ	fresh water	unknown***
WMC-1	11E/04A	Kennetcook	Shubenacadie-Stewiacke		?	?	?	?	?	?	?	?	?	Dresser	?	?	?

* with respect to mean sea level

** Nova Scotia Department of Mines and Energy

***core probably destroyed

CUMBERLAND AREA

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft.(m)	TOTAL DEPTH OF WELL ft.(m)	ELEVATION* OF WELL ft.(m)	ELEVATION OF TOP OF SALT ft.(m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
SR#27-3	11E/13	Pugwash	Beckwith	veins in shales	7(2)	1035(315)	180(55)	-855(-26)	45°46'57"	63°53'35"	31	E	1966	Scurry-Rainbow Ltd.	chips B	?	NSDME**
SR#39-1	11E/13A	Pugwash	Canfield	no salt	no salt	1380(421)	100(30)	———	45°47'50"	63°39'36"	41	L	1966	Scurry-Rainbow Ltd.	chips	?	NSDME
NSDM 961	21H/16A	Amherst	Nappan	beds with gypsum and anhydrite	36(11)	895(273)	50(15)	-729(-222)	45°47'03"	64°14'31"	13	O	1963	NSDM Special Investigation	B	brine	lost
NSDM 962	21H/16A	Amherst	Nappan	beds with gypsum and anhydrite	227(69)	1114.5(340)	50(15)	-838(-255)	45°47'06"	64°14'25"	13	O	1963-64	NSDM Special Investigation	B	brine	lost
Sunoco#1A	21H/16A	Amherst	Nappan	with anhydrite and shale beds	4576(1395)	11504(3506)	50(15)	-1055(-322)	45°47'09"	64°13'48"	13	Q	1946-47	Sun Oil Co. Limited	chips	mud	NSDME
Sunoco#1	21H/16A	Amherst	Nappan	with anhydrite and shale beds	4860(1481)	6499(1981)	50(15)	-1310(-399)	45°47'09"	64°13'48"	13	Q	1945-46	Sun Oil Co. Limited	chips	mud	NSDME
Amherst#1	21H/16A	Amherst	Nappan	with anhydrite and shale beds	3140(957)	4136(1260)	50(15)	-870(-265)	45°47'10"	64°13'16"	35	C	1931	Imperial Oil Limited	chips	mud	GSC***
MSC#43	11E/12C	Oxford	Oxford	veins in brecciated shales	150(46)	410(125)	100(30)	-160(-49)	45°42'34"	63°49'38"	76	C	1953	Malagash Salt Company	B	brine	unknown
MSC#46	11E/13A	Pugwash	Pugwash	with anhydrite	315.5(107)	1013(309)	10(3)	-628(-191)	45°50'42"	63°40'06"	81	Q	1954	Malagash Salt Company	B	brine	unknown
MSC#47	11E/13A	Pugwash	Pugwash	no salt	no salt	796(243)	15(4.5)	———	45°50'57"	63°40'06"	88	A	1954	Malagash Salt Company	B	brine	unknown
MSC#48A (56)	11E/13A	Pugwash	Pugwash	with anhydrite	338(103)	818(249)	15(4.5)	-448(-137)	45°50'36"	63°39'25"	80	L	1954	Malagash Salt Company	B	brine	unknown
MSC#49	11E/13A	Pugwash	Pugwash	with shale breccia	615(187)	1044(318)	15(4.5)	-414(-126)	45°50'10"	63°39'46"	80	D	1954	Malagash Salt Company	B	brine	unknown
MSC#50	11E/13A	Pugwash	Pugwash	with anhydrite	272(83)	745(227)	10(3)	-348(-106)	45°50'45"	63°39'01"	80	Q	1954	Malagash Salt Company	B	brine	unknown
MSC#51	11E/13A	Pugwash	Pugwash	no salt	no salt	640(195)	10(3)	———	45°50'57"	63°38'47"	89	A	1954	Malagash Salt Company	B	brine	unknown
MSC#52	11E/13A	Pugwash	Pugwash	with shale	119(32)	697(213)	15(4.5)	-516(-157)	45°50'51"	63°38'45"	90	D	1954	Malagash Salt Company	B	brine	unknown
MSC#53	11E/13A	Pugwash	Pugwash	in shale and anhydrite	731(223)	997(304)	15(4.5)	-251(-77)	45°50'19"	63°50'19"	80	F	1954	Malagash Salt Company	B	brine	unknown
MSC#55	11E/13A	Pugwash	Pugwash	with anhydrite and shale beds	544(166)	940(286)	10(3)	-386(-118)	45°50'44"	63°39'53"	80	M	1954	Malagash Salt Company	B	brine	unknown
MSC#56	11E/13A	Pugwash	Pugwash	with anhydrite	471(144)	821(250)	10(3)	-340(-104)	45°50'45"	63°39'25"	80	O	1954	Malagash Salt Company	B	brine	unknown
CRSC#8-58	11E/13A	Pugwash	Pugwash	with mudstone	570(174)	1052(321)	10(3)	-430(-131)	45°50'05"	63°41'14"	81	D	1962	Canadian Rock Salt Company Limited	B	brine	unknown
CRSC#8-59	11E/13A	Pugwash	Pugwash	with mud, gypsum and anhydrite	1562(476)	2012(613)	10(3)	-389(-119)	45°50'30"	63°40'40"	81	L	1962	Canadian Rock Salt Company Limited	B	brine	unknown
CRSC#8-60	11E/13A	Pugwash	Pugwash	lost hole, no salt	no salt	450(137)	50(15)	———	45°50'36"	63°40'56"	81	L	1962	Canadian Rock Salt Company Limited	B	brine	unknown
CRSC#8-61A	11E/13A	Pugwash	Pugwash	with anhydrite	992(302)	1352(412)	10(3)	-340(-104)	45°50'25"	63°40'14"	81	M	1962	Canadian Rock Salt	B	brine	unknown
Pacific Fox Harbour C-96-V	11E/13A	Pugwash	Pugwash	with shale	585(178)	9853(3003)	87.9(26.8)	-8697(-2651)KB	45°50'56"	63°30'40"	36	C	1963	Pacific Petroleums Limited	chips	mud	NSDME
NSDM 4307 (Roslin#1)	11E/13B	Pugwash	Roslin	thin veins and beds in mudstone breccia	630(192)	1005(306)	58.7(18)	-316(-96)	45°46'23"	63°46'08"	24	M	1966	Atlantic Development Board	B	brine	NSDME

*with respect to mean sea level **Nova Scotia Department of Mines and Energy ***Geological Survey of Canada

MALAGASH DEPOSIT

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft.(m)	TOTAL DEPTH OF WELL ft.(m)	ELEVATION* OF WELL ft.(m)	ELEVATION OF TOP OF SALT ft.(m)	LOCATION REFERENCE†	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
NSDM 378	11E/14B	Malagash	Malagash	beds with anhydrite	60(18.3)	173(52.7)	———	———	NSMR 1918	1917	G. W. Mackay	B	brine	uncertain***
NSDM 408	11E/14B	Malagash	Malagash	beds with anhydrite	93(28.3) H**	121(36.9)	underground	———	NSMR 1920	1920	Chambers and Mackay	B	brine	uncertain
NSDM 409	11E/14B	Malagash	Malagash	beds with anhydrite	146(44.5) H	146(44.5)	underground	———	NSMR 1920	1920	Chambers and Mackay	B	brine	uncertain
NSDM 588	11E/14B	Malagash	Malagash	beds with anhydrite	61(18.6) H	61(18.6)	underground	———	NSMR 1922	1922	Malagash Salt Company	B	brine	uncertain
NSDM 589	11E/14B	Malagash	Malagash	beds with anhydrite	150(45.7) H	150(45.7)	underground	———	NSMR 1922	1922	Malagash Salt Company	B	brine	uncertain
NSDM 590	11E/14B	Malagash	Malagash	beds with anhydrite	131(4) H	131(40)	underground	———	NSMR 1922	1922	Malagash Salt Company	B	brine	uncertain
NSDM 474	11E/14B	Malagash	Malagash	beds with anhydrite	87(26.5) H	87(26.5)	underground	———	NSMR 1925	1925	Malagash Salt Company	B	brine	uncertain
NSDM 475	11E/14B	Malagash	Malagash	beds with anhydrite and mudstone	118(36) H	118(36)	underground	———	NSMR 1925	1925	Malagash Salt Products	B	brine	uncertain
NSDM 492	11E/14B	Malagash	Malagash	beds with anhydrite and mudstone	36(11) H	36(11)	underground	———	NSMR 1926	1926	Malagash Salt Products	B	brine	uncertain
NSDM 493	11E/14B	Malagash	Malagash	beds with anhydrite	10(3) V**	10(3)	underground	———	NSMR 1926	1926	Malagash Salt Products	B	brine	uncertain
NSDM 495	11E/14B	Malagash	Malagash	beds with anhydrite	7(2.1)	176(53.6)	50(15)	-119(36)	NSMR 1926	1926	Malagash Salt Products	B	brine	uncertain
NSDM 496	11E/14B	Malagash	Malagash	beds with anhydrite	1(0.3)	93(28.3)	50(15)	-42(13)	NSMR 1926	1926	Malagash Salt Products	B	brine	uncertain
NSDM 498	11E/14B	Malagash	Malagash	beds with anhydrite	11(3.4)	116(35.4)	50(15)	-55(17)	NSMR 1926	1926	Malagash Salt Products	B	brine	uncertain
NSDM 499	11E/14B	Malagash	Malagash	beds with anhydrite	16(5)	127(38.7)	50(15)	-61(19)	NSMR 1926	1926	Malagash Salt Products	B	brine	uncertain
NSDM 522	11E/14B	Malagash	Malagash	beds with anhydrite	35(11) H	39(11.9)	underground	———	NSMR 1927	1927	Malagash Salt Products	B	brine	uncertain
NSDM 523	11E/14B	Malagash	Malagash	beds with anhydrite	209(64) H	209(63.7)	underground	———	NSMR 1927	1927	Malagash Salt Products	B	brine	uncertain
NSDM 669	11E/14B	Malagash	Malagash	beds with anhydrite	163(50) H	163(50)	underground	———	NSMR 1928	1928	Malagash Salt Company	B	brine	uncertain
NSDM 670	11E/14B	Malagash	Malagash	beds with anhydrite	168(51) H	168(51.2)	underground	———	NSMR 1928	1928	Malagash Salt Company	B	brine	uncertain
NSDM 671	11E/14B	Malagash	Malagash	beds with anhydrite	15(5) H	15(4.6)	underground	———	NSMR 1928	1928	Malagash Salt Company	B	brine	uncertain
NSDM 672	11E/14B	Malagash	Malagash	beds with anhydrite	85.7(26) H	85.7(26)	underground	———	NSMR 1928	1928	Malagash Salt Company	B	brine	uncertain
NSDM 673	11E/14B	Malagash	Malagash	beds with anhydrite	90.9(28) I**	90.9(37.7)	underground	———	NSMR 1928	1928	Malagash Salt Company	B	brine	uncertain
NSDM 674	11E/14B	Malagash	Malagash	beds with anhydrite	150(46) H	150(45.7)	underground	———	NSMR 1928	1928	Malagash Salt Company	B	brine	uncertain

*with respect to mean sea level

**H = Horizontal
V = Vertical
I = Inclined

***core probably destroyed

†see Nova Scotia Annual Report on the Mines for location

MALAGASH DEPOSIT (continued)

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft. (m)	TOTAL DEPTH OF WELL ft. (m)	ELEVATION* OF WELL ft. (m)	ELEVATION OF TOP OF SALT ft. (m)	LOCATION REFERENCE†		TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
NSDM 675	11E/14B	Malagash	Malagash	beds with anhydrite	105(32) H**	105(32)	underground	———	NSMR 1928				1928	Malagash Salt Company	B	brine	uncertain***
NSDM 919	11E/14B	Malagash	Malagash		71(22) H	486(148)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 920	11E/14B	Malagash	Malagash		452(138) H	452(138)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 921	11E/14B	Malagash	Malagash		585(178) V**	585(178)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 922	11E/14B	Malagash	Malagash		182(55) H	182(55.5)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 923	11E/14B	Malagash	Malagash		115(35) H	115(35)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 924	11E/14B	Malagash	Malagash		140(43) H	140(43)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 925	11E/14B	Malagash	Malagash		190(58) H	190(58)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 926	11E/14B	Malagash	Malagash	beds with anhydrite and mudstone	106(32) I**	106(32.3)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 927	11E/14B	Malagash	Malagash		388(118)H	388(118.3)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 928	11E/14B	Malagash	Malagash		338(103)H	338(103)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 929	11E/14B	Malagash	Malagash		395(120)H	395(120.4)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 930	11E/14B	Malagash	Malagash		310(94) I	310(94)	underground	———	NSMR 1940				1940	Malagash Salt Mine	B	brine	uncertain
NSDM 1850	11E/14B	Malagash	Malagash	beds in shale	208(63)	1212(369)	60(18)	-203(-62)	NSMR 1952		44	A	1952	Malagash Salt Mine	B	brine	uncertain
NSDM 1851	11E/14B	Malagash	Malagash	beds in shale	342(104)	1008(307)	60(18)	-376(-115)	NSMR 1952		29	Q	1952	Malagash Salt Mine	B	brine	uncertain
NSDM 4290 (M-1)	11E/14B	Malagash	Malagash	beds in shale	139(42)	1004(306)	170(52)	-695(-212)	LATITUDE NORTH 45°47'26"	LONGITUDE WEST 63°22'14"	30	N	1965	Atlantic Development Board	B	brine	NSDME**
NSDM 4308 (M-2)	11E/14B	Malagash	Malagash	no salt	no salt	814(248)	90(27)	———	45°47'40"	63°26'08"	40	E	1966	Atlantic Development Board	B	brine	NSDME
Wallace #1	11E/14B	Malagash	Malagash	with mudstone	1239(378)	4011(1223)	248.05KB (75.6)	-2536(-773)	45°46'53"	63°26'52"	34	F	1966	Atlantic Development Board	chips	mud	NSDME
Wallace #2	11E/14B	Malagash	Malagash	with mudstone	454(138) 130(40)	2619(798)	169.0KB (57.5)	-1108(-338)	45°47'24"	63°22'54"	31	K	1966	Atlantic Development Board	chips	mud	NSDME
MSC #42	11E/14B	Malagash	Malagash	in shales	inclusions and veins over 75(21)	655(200)	75(23)	———	———	———	40	D	1953	Malagash Salt Company	B	brine	uncertain
Anschutz Wallace Station No. 1	11E/13A	Pugwash	Malagash	with shales and sandstone	1800(549) 343(105)	14883 (4536.3)	216.5(66)	-10754(-3278) -14345(-4372)	45°46'15"	63°30'30"	24	K	1973	Anschutz Corporation	chips	mud	NSDME

*with respect to mean sea level
**H = Horizontal
V = Vertical
I = Inclined
***core probably destroyed
†see Nova Scotia Annual Report on the Mines for location

ANTIGONISH-MABOU AREA

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft.(m)	TOTAL DEPTH OF WELL ft.(m)	ELEVATION* OF WELL ft.(m)	ELEVATION OF TOP OF SALT ft.(m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
NSDM 1708	11F/12	Antigonish	Southside Harbour	bed in shales	246(75)	1045(319)	20(6)	-759(-231.3)	45°39'13"	61°52'56"	18	P	1951	NSDTI****	H-B	brine	NSDME**
NSDM 1709	11F/12	Antigonish	Southside Harbour	inclusions in anhydrite	79.5(24)	692(211)	20(6)	-232.5(-70.9)	45°39'14"	61°53'33"	17	J	1951	NSDTI	H-B	brine	lost
NSDM 1835	11F/12	Antigonish	Southside Harbour	bed in shales	370(113)	1170(357)	20(6)	-740(-225.6)	45°39'09"	61°52'24"	18	P	1952	NSDTI	H-B	brine	lost
NSDM 1836	11F/12	Antigonish	Southside Harbour	bed in shales	476(145)	1432(436)	20(6)	-744(-226.8)	45°39'11"	61°52'48"	18	P	1952	NSDTI	H-B	brine	lost
Novasel #1 (NSDM 4862)	11F/12	Antigonish	Southside Harbour	bed in gypsum and anhydrite	432(132)	1200(366)	20.5(6.25)	-747.5(-227.8)	45°38'50"	61°52'09"	19	L	1969	Novasel Limited	BQ	brine	St. F. X. University***
NSDM 2671	11F/12	Antigonish	Southside Harbour	veins and inclusions	12(5)	1993(607)	50(15)	-1912(-583)	45°39'43"	61°50'53"	29	L	1958	Lura Corporation	chips	mud	St. F. X. University
BA-SSB-1	11F/12	Antigonish	Southside Harbour	bed with shales	705(215)	3427(1044.5)	30.4(9.27)KB 18.4(5.6)GL	-792(-241)	45°39'15"	61°52'53"	18	P	1975	Brador Oil	chips	mud	NSDME
NSDM 2554	11F/12	Antigonish	Pomquet River	bed in shale and anhydrite	49(15)	1316(401)	35(11)	-1156(-352)	45°34'19"	61°58'47"	68	C	1958	Lura Corporation	chips	fresh water and brine	St. F. X. University
Kenneco #1	11E/09	Merigomish	Antigonish	bed in shales	54(16.5)	1217(371)	75(23)	-972(-296)	45°36'25"	62°02'00"	95	D	1966	Kenneco	BQ	fresh water and brine	NSDME
AP-2-74	11E/09	Merigomish	Antigonish	thin beds and shales	—	1826(557)	75(23)	-1196(-365)	45°35'26"	62°01'15"	73	M	1974	Amax Exploration	BQ-NQ	brine	St. F.X. University
Kenneco #6	11F/12	Antigonish	Pomquet River	veins	—	1222(372.5)	150(46)	-510(-158)	45°33'25"	61°49'00"	45	P	1966	Kenneco Exploration	BQ	fresh water and brine	NSDME
Kenneco #5	11E/09	Merigomish	James River	interbedded with anhydrite	6(2)	1547(472)	130(40)	-430(-131)	45°33'00"	62°06'30"	43	Q	1966	Kenneco Exploration	BQ	fresh water and brine	NSDME
JR#3	11E/09	Merigomish	James River	bed in shales	163(50)	820(250)	210(64)	-447(-136)	45°33'32"	62°07'40"	55	B	1974	Millmac	BQ	brine	lost
AP-1-74	11E/09	Merigomish	James River	bed with shale and anhydrite	698(213)	2216(675.4)	220(67)	-1120(-340)	45°33'43"	62°06'29"	54	E	1974	Amax Exploration	BQ-NQ	brine	Acadia University
AP-1	11E/10	Merigomish	James River	salt not reached	—	912(278)	125(38)	—	45°34'00"	62°06'00"	53	M	1974	Imperial Oil	BQ	brine	Gays River
AM-AB-1	11E/09	Merigomish	Ohio	bed with anhydrite	2(0.6)	980(299)	300(91)	-674(-205)	45°38'43"	62°03'24"	3	O	1970	Maritime Exploration	BQ	fresh water	NSDME
NSDME GM83-1	11E/09	Merigomish	Ohio	vein breccia	11.8(3.6)	2777.0(846.7)	230.6(70.3)	-1686.7(-514.1)	45°33'04"	62°01'40"	47	E	1983	NSDME**	NQ-BQ	brine	NSDME
Mac#1	11K/03	Lake Ainslie	Mabou	beds with anhydrite shale and limestone	4184(1275)	5579(1700.5)	175(53)	-1220(-372)	46°01'40"	61°27'40"	35	B	1966	Lion Oil Company	chips	mud	NSDME
Mary #1	11K/03	Lake Ainslie	Mabou		2300(701)	6869(2094)	200(61)	-4300(-1311)	46°02'15"	61°27'57"	35	E	1956	Lion Oil Company	chips	mud	NSDME
Mabou #1	11K/03	Lake Ainslie	Mabou	veins?	50(15)	5145(1568)	474(144)KB 457(139)GL	-1833(-559)	46°01'30"	61°26'03"	17	E	1959	Imperial Oil	chips	mud	NSDME
Port Hood #1	11K/03	Lake Ainslie	Mabou	beds with anhydrite	3560(1085)	9840(2999)	427(130)KB 410(125)GL	-5690(-1734)	46°01'55"	61°29'00"	36	B	1960	Imperial Oil	chips	mud	NSDME

* with respect to mean sea level
** Nova Scotia Department of Mines and Energy
*** St. Francis Xavier University
**** Nova Scotia Department of Trade and Industry

[illegible]-BRAS D'OR AND STUDY AREAS

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft. (m)	TOTAL DEPTH OF WELL ft. (m)	ELEVATION* OF WELL ft. (m)	ELEVATION OF TOP OF SALT ft. (m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
CIH-1	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	2350(716)	3110(948)	26.2(8)	-733.3(-223.5)	45°52'03"	60°55'24"	105	G	1979	Chevron	chips	salt mud	NSDME**
CIH-2	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	1237(377)	2005(611)	28.7(8.8)	-739(-225.2)	45°52'03"	60°55'23"	105	G	1979	Chevron	chips-4"	salt mud	NSDME
CH-3	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	2915(889)	3838(1170)	19.3(5.9)	-903.3(-275.3)	45°52'04"	60°54'57"	104	S	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-4	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	1955(596)	4006(1221)	13.5(4.1)	-1135.5(-346.1)	45°52'19"	60°55'02"	104	N	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-5	11F/15	Grand Narrows	Malagawatch	no salt	———	1192(363)	57.8(17.6)	———	45°51'37"	60°56'10"	88	N	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-5A	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	2552(778)	3908(1191)	58.0(17.7)	-1208.2(-368.1)	45°51'37"	60°56'10"	88	N	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-6	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	3083(957)	3508(1069)	49.5(15.1)	-975.4(-297.3)	45°52'01"	60°56'58"	106	F	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-7	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	1924(586)	2877(877)	66.2(20.2)	-886.6(-270.2)	45°52'04"	60°56'23"	106	J	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-8	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	3127(953)	3947(1203)	43.2(13.2)	-777.3(-236.9)	45°51'59"	60°55'53"	105	F	1980	Chevron	NQ-BQ	salt mud	NSDME
CH-9	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	3054(931)	3648(1112)	24.8(7.6)	-568.7(-173.3)	45°52'03"	60°55'53"	105	L	1981	Chevron	NQ-BQ	salt mud	NSDME
CH-10	11F/15	Grand Narrows	Malagawatch	beds with anhydrite	1726(526.2)	3218(981)	35.3(10.8)	-676(-206)	45°52'16"	60°58'17"	107	L	1981	Chevron	NQ-BQ	salt mud	NSDME
M225-1	11F/14	Whycocomagh	Orangedale	with shale and anhydrite	1055(322)	2927(892)	35(10.7)	-1837(-560)	45°56'13"	61°08'02"	55	G	1978	Noranda	NQ-BQ	salt mud	Orangedale
M225-2A	11F/14	Whycocomagh	Orangedale	no salt	———	467(142)	60(18)	———	45°53'44"	61°06'20"	19	J	1980	Noranda	NQ-BQ	mud	Orangedale
M225-3	11F/14	Whycocomagh	Orangedale	with shale and anhydrite	1620(494)	2474(754)	112(34)	-808(-246)	45°54'12"	61°06'50"	30	C	1980	Noranda	NQ-BQ	salt mud and brine	Orangedale
M225-4	11F/14	Whycocomagh	Orangedale	with shale and anhydrite	2376(724)	2935(895)	121(37)	-440(-134)	45°54'49"	61°07'37"	18	G	1980	Noranda	NQ-BQ	salt mud and brine	Orangedale
M225-5A	11F/14	Whycocomagh	Orangedale	with shale and anhydrite	2567(782)	3537(1078)	59(18)	-911(-278)	45°53'41"	61°07'47"	15	B	1981	Noranda	NQ-BQ	salt mud and brine	Orangedale
St. Peters 01	11F/10	St. Peters	St. Peters	mixed in shales	429(131)	1886(575)	15(4.6)	-1450(-442)	45°38'01"	60°53'54"	17	Q	1968	Domtar	NQ-BQ	brine	NSDME
St. Peters 03(2)	11F/10	St. Peters	St. Peters	beds in shales	1811(552)	3038(925)	15(4.6)	-1210(-369)	45°38'53"	60°53'35"	18	M	1968	Domtar	NQ-BQ	brine	NSDME
Seaview 02	11F/10	St. Peters	Seaview	in shales	484(147)	2166(660)	100(30)	-1600(-488)	45°40'59"	60°56'58"	50	C	1968	Domtar	NQ-BQ	brine	NSDME?
Port Richmond 01	11F/11	Port Hawkesbury	Port Richmond	beds with anhydrite	836(255)	2504(763)	50(15)	-1617(-493)	45°35'44"	61°15'06"	73	Q	1967	Dow Chemical	NQ-BQ	brine	Dow?
Port Richmond 02	11F/11	Port Hawkesbury	Port Richmond	beds with anhydrite	308(94)	2401(732)	50(15)	-1752(-534)	45°34'59"	61°15'47"	73	G	1967	Dow Chemical	NQ-BQ	brine	Dow?
Port Richmond 03	11F/11	Port Hawkesbury	Port Richmond	with shale breccias	3197(974)	5172(1576)	50(15)	-1683(-513)	45°35'21"	61°15'21"	72	O	1968	Dow Chemical	NQ-BQ	brine	Dow?
DCPR 11 redrill of PR01	11F/11	Port Hawkesbury	Port Richmond	with anhydrite and shales	2358(719)	4025(1227)	61.5(19)	-1617(-493)	45°35'44"	61°15'06"	73	Q	1973	Dow Chemical	NQ-BQ	brine	NSDME
Port Malcolm 01	11F/11	Port Hawkesbury	Port Richmond	beds with anhydrite and limestone	1121(342)	2047(620)	40(12)	-887(-270)	45°35'50"	61°16'25"	84	P	1972	Dow Chemical	NQ-BQ	brine	NSDME

*with respect to mean sea level

**Nova Scotia Department of Mines and Energy

CANSO-BRAS D'OR AND SYDNEY AREAS (continued)

DRILLHOLE	NTS	MAP AREA	DEPOSIT OR OCCURRENCE	MODE OF OCCURRENCE	THICKNESS OF INTERSECTION(S) ft. (m)	TOTAL DEPTH OF WELL ft. (m)	ELEVATION* OF WELL ft. (m)	ELEVATION OF TOP OF SALT ft. (m)	LATITUDE NORTH	LONGITUDE WEST	TRACT	CLAIM	YEAR DRILLED	OPERATOR	CORE SIZE	DRILL FLUID	CORE/CHIPS STORED
NSDM 6108 (C1L81)	11F/11	Port Hawkesbury	Port Richmond	beds with anhydrite, limestone and siltstone	1411(430)	2230(680)	40(12)	-778(-237)	45°35'28"	61°14'51"	64	E	1967	Dow Mining and Exploration	BQ	brine	NSDME**
Kingsville #3	11F/14	Whycocomagh	Kingsville		1656(505)	3006(916)	50(15.2)	-1300(-396)	45°46'39"	61°19'25"	21	O	1968	Domtar	NQ-BQ	brine	NSDME
Kingsville #4	11F/14	Whycocomagh	Kingsville		892(272)	2512(766)	50(15.2)	-1570(-478)	45°47'03"	61°20'13"	29	J	1968	Domtar	NQ-BQ	brine	NSDME
Kingsville #5	11F/14	Whycocomagh	Kingsville		1656(505)	3086(941)	100(30.5)	-1330(-405)	45°46'21"	61°19'53"	21	M	1968	Domtar	NQ-BQ	brine	NSDME
DK-6	11F/14	Whycocomagh	Kingsville		2228(679)	3936(1199.7)	100(30.5)	-1609(-490.5)	45°45'23"	61°20'30"	5	G	1968	Domtar	NQ-BQ	brine	NSDME
DK-7	11F/14	Whycocomagh	Kingsville		2355(718)	4008(1221.6)	100(30.5)	-1555(-474)	45°45'26"	61°20'31"	5	G	1968	Domtar	NQ-BQ	brine	NSDME
DK-8	11F/14	Whycocomagh	Kingsville		2587(789)	4005(1220.7)	50(15)	-1368(-417)	45°46'04"	61°20'23"	20	B	1969	Domtar	NQ-BQ	brine	NSDME
DK-9	11F/14	Whycocomagh	Kingsville		2716(828)	4018(1224.7)	50(15)	-1253(-382)	45°46'52"	61°19'47"	20	E	1969	Domtar	NQ-BQ	brine	NSDME
DK-10	11F/14	Whycocomagh	Kingsville		2500(706)	4007(1221.3)	100(30.5)	-1329(-405)	45°46'23"	61°20'10"	20	J	1969	Domtar	NQ-BQ	brine	NSDME
DK-11	11F/14	Whycocomagh	Kingsville		2656(810)	4057(1236.6)	100(30.5)	-1352(-412)	45°46'29"	61°20'02"	20	J	1969	Domtar	NQ-BQ	brine	NSDME
DK-12	11F/14	Whycocomagh	Kingsville		2436(742)	3882(1183.2)	50(15)	-1396(-426)	45°46'06"	61°20'12"	20	B	1969	Domtar	NQ-BQ	brine	NSDME
KSM-1	11F/14	Whycocomagh	Kingsville		2700(823)	3985(1215)	49.9(15)	-1235(-376)	45°46'53"	61°19'48"	20	E	1971	Domtar	NQ-BQ	brine	NSDME
Canso Strat #1	11F/11	Port Hawkesbury	McIntyre Lake		1358(416)	2200(671)	44.36 (13.52)	-798(-243)	45°40'07"	61°16'48"	43	B	1972	Murphy Oil Ltd. (Northern Canadian Oil Ltd.)	NQ-BQ	brine	NSDME
Canso Strat #2	11F/11	Port Hawkesbury	McIntyre Lake		2171(662)	3007(917)	112(34.14)	-726(-221)	45°38'50"	61°17'10"	23	M	1974	Murphy Oil Ltd. (Northern Canadian Oil Ltd.)	NQ-BQ	brine	NSDME
NSDME 3630	11K/01	Sydney	East Bay	mixed with anhydrite	9(3)	1050(32)	75(23)	-557(-170)	46°01'45"	60°17'56"	27	B	1962	Morton Chemical Company	NQ-BQ	brine	NSDME
NSDME Kempt Head 84-1	11K/02	Baddeck	Boularderie	beds with mudstone, potash and anhydrite	32(9.7) 1106(337.1)	3094.5(943.2)	91(27.7)	-1324(-403.5)	46°04'33"	60°30'33"	66	E	1984	NSDME**	NQ-BQ	brine	NSDME
N227-2	11F/11	Port Hawkesbury	Cleveland	beds with anhydrite	1054(321)	3457(1054)	199.5(61)	-2203.5(-671.6)	45°39'00"	61°09'30"	32	D	1981	Noranda	NQ-BQ	salt mud	Orangedale
N227-1	11F/15	Grand Narrows	Estmere	beds with shale	1514(461)	2822(860)	15(4.5)	-1323(-403)	45°56'57"	60°38'13"	35	O	1981	Noranda	NQ-BQ	salt mud	Orangedale
B1/81W	11K/02	Baddeck	St. Patricks Channel	beds with anhydrite	2591(790)	3890(1186)	64.6(19.7)	-1234(-376.1)	46°02'05"	60°55'13"	33	K	1981	Chevron	NQ-BQ	salt mud	NSDME

* with respect to mean sea level
**Nova Scotia Department of Mines and Energy

APPENDIX 2

CHEMICAL ANALYSES

SALT ROCKS AND SALT BRINES

BEAVER BROOK DEPOSIT, HANTS-COLCHESTER AREA

Chemical analyses* NSDM 4735 (BB-2, SD-2);
Composite samples of 2"-3" whole cores

Sample Footage (ft.)	% Insoluble	% Br	% K	% Ca	% Mg	% SO_4	% PO_4**
Lower Salt							
2067.8-2102.5	4.62	0.0085	0.02	0.76	0.0014	0.38	0.01
2102.5-2162.5	14.38	0.0057	0.05	4.42	0.0001	0.56	0.01
2162.5-2187.5	1.20	0.0070	0.09	1.12	0.0010	0.79	0.01
2187.5-2262.5	33.96	0.0043	0.04	4.70	0.0019	2.43	0.01
2262.5-2322.5	2.70	0.0080	0.02	1.20	0.0070	0.83	0.01
2322.5-2404.0	2.00	0.0047	0.25	4.36	0.0006	2.08	0.01
Upper Salt							
1286.0-1327.5	12.86	0.0048	0.01	2.60	0.0005	1.72	0.01
1327.5-1350.0	4.36	0.0038	0.01	1.60	0.0009	0.99	0.01

Sample Footage (ft.)	% Sr	% Soluble NaCl	% Cl	% Na	% $CaSO_4$	% $CaCl_2$
Lower Salt						
2067.8-2102.5	0.002	97.99	59.73	37.10	0.54	1.66
2102.5-2162.5	0.005	88.04	48.28	29.68	0.79	11.60
2162.5-2187.5	0.002***	96.41	61.32	37.70	1.11	2.21
2187.5-2262.5	0.008	83.07	34.97	21.60	3.43	10.25
2262.5-2322.5	0.002***	94.89	59.82	36.35	1.17	2.38
2322.5-2404.0	0.004	87.36	53.78	33.65	2.93	9.72
Upper Salt						
1286.0-1327.5	0.004	91.68	50.94	31.45	2.43	5.21
1327.5-1350.0	0.002***	92.62	57.69	34.88	1.40	3.30

Chemical analyses* NSDM 4735 (BB-2; SD-2);
Upper salt 2"-3" full-core samples

Sample Footage (ft.)	% NaCl	% Insolubles	% LOI	% NaCl on Soluble $100-\left[\begin{matrix}\text{LOI+}\\\text{Insoluble}\\\text{Residue}\end{matrix}\right]$
1290	88.80	1.42	0.16	90.33
1295	85.09	7.95	0.16	92.60
1300	77.22	12.66	0.20	88.62
1305	72.39	13.87	0.16	80.46
1310	88.39	8.84	0.12	96.98
1315	82.55	11.63	0.12	93.54
1320	88.90	2.59	0.18	91.43
1325	46.49	41.09	1.14	8.47
1330	88.77	6.47	0.25	95.17
1335	93.09	3.14	0.21	96.32
1340	91.95	3.86	0.22	95.86
1345	95.77	4.07	0.15	99.98
1350	92.97	5.88	0.32	99.12

Quantitative analysis of salt samples

Sample Footage (ft.)	Loss on Ignition	Insoluble Residue	As 100% Soluble Matter					
			NaCl	$CaSO_4$	Br	KCl	$SrSO_4$	$MgCl_2$
1323	0.17	1.32	97.6	1.19	0.0010	0.02	0.034	0.0
1342	0.37	1.28	98.7	0.97	0.0037	0.01	Nil	Nil
1368.5	0.18	0.77	96.9	1.01	0.0023	0.02	0.034	0.0
1390.5	2.40	54.00	596.1	1.74	0.0046	0.02	0.20	0.0

*Analysis by Nova Scotia Research Foundation (1968c) **PO_4 less than 0.01 per cent in all analyses ***Sr less than 0.002 per cent

BEAVER BROOK DEPOSIT, HANTS-COLCHESTER AREA

Chemical analyses NSDM 4735 (BB-2, SD-2): Lower salt 2"-3" full core samples*

Sample Footage Depth (ft.)	% NaCl	% Insoluble Residue	% LOI	% NaCl on Soluble $100-\left[\text{LOI}+\text{Insoluble Residue}\right]$
2070	94.74	2.20	0.01	96.88
2075	96.01	1.37	0.01**	97.34
2080	95.25	0.96	0.03	96.20
2085	93.47	2.51	0.04	95.92
2090	90.93	2.17	0.01	92.96
2095	93.73	1.53	0.01**	95.19
2100	93.45	1.09	0.03	94.51
2105	54.48	26.74	0.01**	74.37
2110	89.15	2.04	0.01**	91.00
2115	43.69	36.36	0.10	68.76
2120	68.32	19.28	0.06	84.76
2125	74.93	15.44	0.06	88.67
2130	50.55	35.56	0.15	78.63
2135	37.60	50.48	0.09	76.07
2140	70.36	14.40	0.02	82.21
2145	85.98	5.46	0.04	90.95
2150	83.06	8.50	0.08	90.86
2155	89.10	2.93	0.10	91.88
2160	76.46	15.25	0.69	90.96
2165	91.95	1.79	0.08	93.70
2170	91.95	1.98	0.10	93.90
2175	93.98	2.03	0.10	96.02
2180	91.96	1.55	0.03	93.44
2185	93.85	1.27	0.08	95.13
2190	9.20	77.76	1.06	43.44
2195	74.80	11.37	0.02	84.41
2200	73.40	13.40	0.28	85.03
2205	95.50	2.62	0.17	98.24
2210	23.62	66.45	0.21	70.86
2215	71.88	19.85	0.33	90.05
2220	71.88	23.04	0.75	93.32
2225	54.35	31.93	0.10	79.96
2230	95.50	1.74	0.01	97.19
2235	65.28	27.16	0.08	89.72
2240	73.66	17.52	0.08	89.39
2245	27.43	62.64	0.14	73.70
2250	21.43	66.29	0.14	63.78
2255	31.24	55.25	0.15	69.92
2260	53.29	41.52	0.09	91.27
2265	83.82	12.60	0.09	96.00
2270	95.50	2.41	0.01	97.87
2275	95.50	2.67	0.07	98.19
2280	95.50	1.93	0.11	97.49
2285	85.85	7.52	0.02	92.85
2290	95.50	2.12	0.38	97.95
2295	97.03	1.63	0.03	98.67
2300	97.03	2.54	0.01	99.57
2305	93.47	3.38	0.25	96.99
2310	95.50	3.17	0.45	99.09
2315	97.03	1.82	0.07	98.90
2320	97.03	0.67	0.30	100.00
2325	80.01	6.01	0.30	85.40
2330	82.80	5.24	0.38	87.73
2335	82.80	1.82	0.16	84.39
2340	82.80	3.60	0.13	86.00
2345	81.28	8.77	0.36	89.43
2350	77.72	8.16	0.41	85.02
2355	80.26	5.58	0.31	85.28
2360	82.80	2.17	0.12	89.31
2365	83.82	2.13	0.13	85.76
2370	81.28	4.53	0.24	85.35
2375	81.28	2.83	0.20	83.82
2380	77.72	7.75	0.35	84.57
2385	82.80	4.53	0.27	86.91
2390	85.09	7.61	0.37	92.17
2395	87.38	2.41	0.16	89.68
2400	85.34	6.43	0.32	91.52
2405	87.38	3.80	0.23	91.05

*Nova Scotia Research Foundation (1968c) **less than 0.01

SHUBENACADIE-STEWIACKE DEPOSIT DRILLHOLES 153-1 AND SB-1 CHEMICAL ANALYSIS

Sampling Procedure

Samples submitted for major and trace element analyses were composed of continuous halved diamond-drill core (1.85 inch (NQ) and 1.4 inch (BQ)) over intervals of 10 feet (3 m). A total of 192 intervals was sampled in this manner to give a continuous sequence of analyses through the entire salt sections of drillholes 153-1 and SB-1. Major anhydrite interbeds thicker than approximately one foot were not sampled. Each of the 10 foot intervals, numbered sequentially from top to base, were sampled in two parts each five feet thick and given an a and b subscript (upper and lower subsamples). Analyses were performed upon composites of the subsamples with the individual subsamples retained for further detailed analyses when required.

Samples were placed in plastic bags and sent to Nova Scotia Technical College for sample preparation and analyses.

Sample Preparation

Samples were crushed as received to -10 mesh through a jaw crusher and cone crusher. A sample for analyses was split out with a Jones splitter, dried at 110°C in an oven and crushed to -200 mesh in a shatterbox.

Analytical Methods

One gram of prepared sample was weighed, placed in a 250 ml beaker and 100 ml of distilled water added. The beaker was placed in a magnetic stirrer and stirred for 10 minutes at ambient room temperature. The mixture was filtered through ashless filter paper. The filtrate was saved and the filter paper was washed six times with distilled water to remove the remaining filtrate. The insoluble residue was measured gravimetrically after the filter paper was ashed. The filtrate collected was analyzed forCl using the method of Volhord, (silver nitrate titration) Scotts Standard Methods of Chemical Analysis, 5th Edition, p. 271.

CaO, MgO, Na_2O, K_2O, Fe_2O_3 were all determined by atomic absorption spectrophotometry using the following procedure. Samples weighing 1/10 of a gram were fused with Shapiro's mix in a graphite crucible at 1050° C, leached with dilute nitric acid and filtered into a volumetric flask. To this solution strontium is added to supress ionization and chemical interferences. CaO, MgO, Na_2O, K_2O and Fe_2O_3 are determined by atomic absorption spectrophotometry. CaO and MgO require a nitrous oxide-acetylene flame, and Na_2O, K_2O and Fe_2O_3 are analyzed using air-acetylene flame.

Rb was determined by atomic absorption spectrophotometry using the method in Chemical Methods of Rock Analysis V36 by P. G. Jeffery.

Br was determined using the thiosulphate titration method described by Crosby (1975) in New Brunswick Department of Natural Resources, Topical Report 75-18, p. 16-18.

CO_2 was determined using the modified apparatus of Knorr (Fisher, Alkalimeter) described in Scotts Standard Methods of Chemical Analysis 5th Edition, p. 235-236.

SO_4 was determined gravimetrically using the method in Scotts Standard Methods of Chemical Analysis, 5th Edition, p. 908-909.

B and Sr were determined using emission spectrometry.

SHUBENACADIE-STEWIACKE DEPOSIT - HANTS-COLCHESTER AREA   Chemical analyses drillholes 153-1 and SB-1

SAMPLE	INTERVAL (FEET)	PERCENTAGE									PARTS PER MILLION					MINERALS		TOTALS	
		NA2O	CL	CAO	SO4	CO2	MGO	K2O	FE2O3	INSOL	BR	SR	RB	B	U2O3	NACL FROM CL	CASO4 FROM SO4	WITHOUT INSOL	WITH INSOL
153- 1	705.0- 716.0	51.8	56.8	2.29	3.84	.16	.06	.04	.02	42	77.	150.	1.	ND	<1.	93.5	5.5	99.0	99.4
153- 2	993.0-1003.0	43.5	54.0	1.46	2.65	.23	.28	.18	.33	6.56	85.	190.	1.	148.	4.	89.0	3.8	92.7	99.2
153- 3	1003.0-1013.0	48.5	53.0	1.81	3.17	.27	.36	.22	.39	7.84	101.	100.	13.	80.	<1.	87.3	4.5	91.7	99.6
153- 4	1013.0-1023.0	41.6	49.0	1.75	2.69	.39	.52	.28	.61	13.89	85.	110.	15.	ND	<1.	80.8	3.8	84.7	98.6
153- 5	1023.0-1033.0	49.2	55.0	1.16	1.57	.30	.28	.16	.31	6.43	95.	22.	4.	ND	<1.	90.7	2.2	93.1	99.5
153- 6	1033.0-1043.0	44.5	49.6	4.77	7.73	.23	.35	.16	.33	7.61	58.	160.	6.	ND	<1.	81.7	11.0	92.8	100.4
153- 7	1043.0-1053.0	49.2	56.4	1.89	2.98	.31	.19	.07	.11	2.14	104.	80.	6.	ND	<1.	93.0	4.2	97.3	99.5
153- 8	1053.0-1063.0	48.0	54.5	1.61	2.74	.22	.29	.18	.29	5.78	77.	100.	4.	ND	<1.	89.8	3.9	93.7	99.5
153- 9	1063.0-1073.0	52.9	56.6	1.33	1.79	.49	.19	.10	.17	3.52	90.	40.	4.	ND	<1.	93.3	2.5	96.0	99.6
153-10	1073.0-1083.0	46.3	57.0	1.38	1.76	.25	.25	.13	.23	3.34	77.	55.	4.	ND	<1.	93.9	2.5	96.7	100.0
153-11	1083.0-1093.0	39.0	45.0	2.80	4.38	.30	.40	.48	.78	18.95	69.	120.	15.	ND	<1.	74.1	6.2	80.5	99.4
153-12	1093.0-1103.0	45.9	55.4	2.06	2.81	.24	.26	.09	.21	3.98	99.	68.	3.	ND	<1.	91.3	4.0	95.6	99.6
153-13	1103.0-1113.0	41.9	52.5	2.92	4.69	.28	.41	.13	.29	6.13	74.	125.	5.	ND	<1.	86.5	6.7	93.3	99.4
153-14	1113.0-1123.0	47.4	57.8	1.45	2.34	.11	.06	.03	.05	.51	96.	28.	1.	ND	<1.	95.2	3.3	98.6	99.1
153-15	1123.0-1133.0	48.0	58.0	1.29	2.11	.31	.20	.07	.13	1.74	79.	50.	1.	ND	<1.	95.5	3.0	98.5	100.3
153-16	1133.0-1143.0	51.8	58.1	1.21	1.93	.25	.13	.07	.07	1.86	83.	55.	1.	ND	<1.	95.7	2.7	98.5	100.4
153-17	1143.0-1153.0	51.0	57.9	1.31	1.95	.22	.15	.07	.07	1.74	113.	28.	1.	ND	<1.	95.3	2.8	98.2	100.0
153-18	1153.0-1163.0	50.7	57.8	1.18	1.80	.17	.18	.03	.15	2.24	121.	45.	1.	ND	<1.	95.3	2.6	97.9	100.2
153-19	1163.0-1173.0	49.8	55.9	2.50	3.99	.26	.23	.07	.15	2.07	118.	70.	1.	ND	<1.	92.1	5.7	97.9	100.0
153-20	1173.0-1183.0	45.8	51.9	3.08	5.29	.27	.42	.39	.31	6.48	89.	215.	1.	130.	<1.	85.5	7.5	93.0	99.4
153-21	1183.0-1193.0	44.7	55.1	2.12	3.68	.17	.30	.10	.17	4.53	107.	65.	4.	ND	<1.	90.8	5.2	96.0	100.6
153-22	1193.0-1203.0	48.6	57.8	1.71	2.90	.22	.11	.05	.05	.64	91.	50.	1.	ND	<1.	95.3	4.1	99.4	100.0
153-23	1203.0-1213.0	50.8	57.4	1.05	1.67	.20	.22	.21	.10	2.50	94.	43.	1.	ND	<1.	94.6	2.4	97.1	99.6
153-24	1213.0-1223.0	36.1	41.4	10.90	18.35	.53	.35	.11	.25	5.81	83.	340.	1.	95.	<1.	68.2	26.1	94.4	100.2
153-25	1223.0-1233.0	37.8	44.4	9.76	14.63	.50	.24	.07	.19	4.83	81.	180.	3.	85.	<1.	73.2	20.8	94.8	99.7
153-26	1233.0-1243.0	32.2	35.1	17.23	28.32	.52	.19	.05	.10	12.73	70.	395.	1.	88.	<1.	57.8	40.2	98.5	111.2
153-27	1243.0-1253.0	52.2	56.9	2.36	3.24	.20	.09	.05	.08	.95	85.	120.	1.	ND	<1.	93.8	4.6	98.7	99.7
153-28	1253.0-1263.0	51.1	58.4	1.16	1.84	.17	2.52	.05	.07	1.71	89.	15.	1.	ND	<1.	96.2	2.6	98.9	100.6
153-29	1263.0-1273.0	42.3	46.5	6.33	11.98	.39	.48	.19	.27	7.35	134.	205.	1.	<45.	<1.	76.6	17.0	93.2	100.5
153-30	1273.0-1283.0	52.7	57.4	1.31	2.15	.26	.07	.07	.04	.70	145.	40.	1.	ND	<1.	94.6	3.1	97.7	98.4
153-31	1283.0-1293.0	37.6	44.4	3.98	5.03	.37	1.00	.47	.63	17.86	173.	225.	<1.	205.	<1.	73.1	7.1	81.0	98.9
153-32	1293.0-1303.0	48.8	57.2	1.36	1.78	.15	.14	.08	.11	1.85	178.	330.	2.	ND	<1.	94.2	2.5	96.9	98.8
153-33	1303.0-1313.0	47.7	53.6	4.04	6.46	.38	.20	.07	.10	2.14	101.	160.	1.	ND	<1.	88.3	9.2	97.7	99.8
153-34	1313.0-1323.0	50.6	56.4	1.75	2.53	.43	.11	.08	.04	1.14	145.	50.	1.	ND	<1.	93.0	3.6	96.8	97.9
153-35	1323.0-1333.0	46.9	52.5	4.64	7.90	.27	.14	.05	.09	2.16	134.	145.	1.	ND	<1.	86.6	11.2	97.8	100.0

SHUBENACADIE-STEWIACKE DEPOSIT - HANTS-COLCHESTER AREA Chemical analyses drillholes 153-1 and SB-1

SAMPLE	INTERVAL (FEET)	PERCENTAGE									PARTS PER MILLION					MINERALS		TOTALS	
		NA2O	CL	CAO	SO4	CO2	MGO	K2O	FE2O3	INSOL	BR	SR	RB	B	U2O3	NACL FROM CL	CASO4 FROM SO4	WITHOUT INSOL	WITH INSOL
153-36	1333.0-1343.0	47.6	56.9	1.74	2.54	.27	.17	.10	.16	2.56	140.	95.	<1.	90.	<1.	93.8	3.6	97.6	100.1
153-37	1343.0-1353.0	47.6	55.4	2.49	3.34	.45	.19	.08	.12	2.34	132.	70.	<1.	ND	<1.	91.3	4.7	96.4	98.7
153-38	1353.0-1363.0	48.2	57.5	1.20	2.03	.20	.11	.09	.07	1.25	126.	80.	1.	ND	<1.	94.8	2.9	97.7	98.9
153-39	1363.0-1373.0	47.6	56.1	2.67	3.87	.32	.15	.07	.04	1.89	148.	85.	1.	ND	<1.	92.5	5.5	98.3	100.2
153-40	1373.0-1382.0	44.9	53.3	2.85	5.11	.17	.22	.15	.16	3.94	178.	70.	<1.	80.	<1.	87.8	7.3	94.9	98.8
153-41	1397.0-1410.0	40.3	46.7	7.58	12.81	.40	.47	.08	.16	6.81	107.	410.	1.	65.	<1.	76.9	18.2	95.2	102.0
153-42	1410.0-1420.0	49.0	54.1	2.77	4.38	.28	.19	.09	.15	2.65	175.	74.	1.	ND	<1.	89.2	6.2	95.6	98.2
153-43	1420.0-1430.0	50.4	55.7	2.57	4.04	.36	.18	.07	.10	1.84	126.	93.	1.	ND	<1.	91.8	5.7	97.7	99.6
153-44	1430.0-1440.0	39.4	41.7	9.81	18.31	.68	.50	.11	.19	10.91	134.	430.	2.	135.	<1.	68.7	26.0	94.1	105.0
153-45	1440.0-1450.0	47.9	54.3	2.00	4.33	.35	.24	.11	.17	3.52	137.	70.	1.	ND	<1.	89.5	6.1	95.3	98.8
153-46	1450.0-1460.0	33.5	37.2	14.62	25.46	.48	.20	.07	.13	14.75	85.	370.	1.	80.	<1.	61.3	36.2	97.3	112.0
153-47	1460.0-1470.0	43.9	49.4	6.62	11.40	.19	.11	.05	.07	3.27	93.	425.	2.	80.	<1.	81.4	16.2	97.5	100.8
153-48	1470.0-1480.0	51.6	58.2	1.12	1.78	.35	.07	.05	.07	1.33	96.	80.	2.	ND	<1.	95.9	2.5	98.5	99.8
153-49	1480.0-1490.0	48.0	55.0	4.36	5.48	.25	.08	.05	.07	1.50	115.	175.	1.	ND	<1.	90.6	7.8	99.2	100.7
153-50	1490.0-1500.0	37.2	41.6	11.30	20.93	.33	.02	.07	.11	12.01	85.	370.	1.	100.	<1.	68.5	29.7	97.5	109.5
153-51	1500.0-1510.0	44.3	50.5	5.01	7.89	.20	.24	.10	.18	7.55	77.	170.	1.	<45.	<1.	83.3	11.2	94.7	102.3
153-52	1510.0-1520.0	49.6	56.6	2.01	3.92	.17	.07	.04	.05	.99	107.	65.	1.	ND	<1.	93.3	5.6	98.7	99.6
153-53	1520.0-1530.0	49.6	57.7	2.22	3.45	.36	.03	.04	<.01	.22	112.	33.	1.	ND	<1.	95.1	4.9	100.1	100.4
153-54	1530.0-1539.7	46.7	57.6	1.84	3.41	.14	.06	.04	<.01	.34	88.	55.	1.	ND	<1.	95.0	4.8	99.7	100.1
153-55	1539.7-1554.1	31.6	34.1	11.96	19.73	.44	1.33	.56	.69	22.47	69.	455.	23.	155.	<1.	56.3	28.0	84.6	107.0
153-56	1560.6-1570.6	32.6	37.7	14.44	25.16	.49	.23	.10	.19	13.31	99.	370.	1.	165.	<1.	62.0	35.7	97.6	110.9
153-57	1570.6-1580.6	44.9	53.2	4.59	7.99	.01	.11	.04	.06	1.62	74.	105.	<1.	ND	<1.	87.7	11.3	99.0	100.6
153-58	1580.6-1590.6	47.1	52.2	3.96	7.32	.24	.16	.07	.11	2.74	92.	134.	<1.	<45.	<1.	86.0	10.4	96.2	98.9
153-59	1590.6-1600.6	34.8	40.8	12.36	20.99	.16	.29	.06	.15	10.96	26.	365.	<1.	80.	<1.	67.3	29.8	97.1	108.1
153-60	1600.6-1610.6	46.3	54.7	2.89	5.28	.20	.08	.05	.08	1.75	69.	147.	<1.	50.	<1.	90.1	7.5	97.4	99.2
153-61	1610.6-1620.6	44.7	57.2	1.69	2.46	.01	.11	.06	.04	1.43	69.	50.	1.	ND	<1.	94.2	3.5	97.9	99.3
153-62	1620.6-1630.6	33.6	40.7	12.63	22.14	.25	.20	.09	.15	11.34	69.	600.	5.	185.	<1.	67.0	31.4	98.2	109.5
153-63	1630.6-1640.6	33.1	37.6	15.24	25.98	.29	.18	.07	.12	14.80	53.	475.	4.	165.	<1.	62.0	36.9	98.9	113.7
153-64	1640.6-1649.6	46.0	51.4	5.56	9.84	.20	.09	.04	.06	1.93	74.	165.	2.	ND	<1.	84.7	14.0	98.5	100.5
153-65	1653.8-1663.8	49.6	57.9	1.45	2.14	.21	.07	.04	.04	3.66	74.	46.	1.	ND	<1.	95.3	3.0	98.5	102.2
153-66	1663.8-1673.8	47.1	55.7	2.95	5.55	.10	.06	.05	.05	1.03	99.	130.	1.	ND	<1.	91.8	7.9	99.5	100.5
153-67	1673.8-1683.8	46.6	52.9	4.80	8.38	.04	.07	.05	.07	1.02	99.	205.	<1.	ND	<1.	87.2	11.9	99.0	100.0
153-68	1683.8-1693.8	49.7	56.1	2.07	3.28	.10	.09	.07	.07	1.52	104.	65.	<1.	50.	<1.	92.4	4.7	97.2	98.7
153-69	1693.8-1703.8	43.6	48.6	6.51	12.45	.20	.10	.08	.08	4.51	82.	338.	<1.	85.	<1.	80.1	17.7	97.3	101.8
153-70	1703.8-1713.8	48.0	57.9	.87	1.26	.09	.08	.06	.04	1.24	143.	16.	<1.	125.	<1.	95.3	1.8	97.2	98.5

SHUBENACADIE-STEWIACKE DEPOSIT - HANTS-COLCHESTER AREA   Chemical analyses drillholes 153-1 and SB-1

SAMPLE	INTERVAL (FEET)	PERCENTAGE									PARTS PER MILLION					MINERALS		TOTALS	
		NA2O	CL	CAO	SO4	CO2	MGO	K2O	FE2O3	INSOL	BR	SR	RB	B	U2O3	NACL FROM CL	CASO4 FROM SO4	WITHOUT INSOL	WITH INSOL
153-71	1713.8-1723.8	46.2	57.2	1.92	2.86	.16	.01	.08	<.01	.18	27.	52.	<1.	ND	<1.	94.2	4.1	98.4	98.6
153-72	1723.8-1737.0	50.3	57.3	2.06	3.50	.29	.02	.11	<.01	1.35	104.	56.	<1.	ND	<1.	94.3	5.0	99.3	100.7
153-73	1742.1-1752.0	44.9	49.0	6.22	14.47	.16	.10	.05	.02	9.55	82.	305.	<1.	ND	<1.	80.8	20.5	99.7	109.3
153-74	1752.0-1762.0	41.2	43.7	9.46	18.23	.45	.16	.07	.09	15.22	93.	355.	<1.	ND	<1.	72.0	25.9	97.1	112.3
153-75	1762.0-1775.0	53.1	58.2	.79	1.33	.10	.07	.05	.03	1.17	99.	66.	<1.	ND	<1.	95.9	1.9	97.8	99.0
153-76	1779.3-1789.3	43.0	49.6	8.71	12.85	.09	.08	.05	.03	8.21	66.	170.	<1.	ND	<1.	81.8	18.2	100.9	109.1
153-77	1789.3-1795.2	50.1	56.0	2.65	4.60	.09	.08	.07	.07	2.18	79.	85.	<1.	ND	<1.	92.3	6.5	98.8	101.0
153-78	1799.0-1809.0	50.4	58.1	2.29	2.24	.20	.04	.06	<.01	.63	153.	5.	<1.	ND	<1.	95.8	3.2	99.7	100.3
153-79	1809.0-1813.8	52.5	57.6	1.87	3.08	.18	.05	.03	<.01	1.02	137.	45.	<1.	ND	<1.	94.9	4.4	99.4	100.4
153-80	1816.8-1826.8	53.4	59.1	.61	1.42	.21	.08	.06	.02	.83	112.	18.	<1.	ND	<1.	97.4	2.0	99.2	100.1
153-81	1826.8-1837.0	45.1	49.5	6.81	12.89	.08	.08	.07	.03	3.62	82.	315.	1.	ND	<1.	81.5	18.3	99.3	102.9
153-82	1837.0-1847.0	53.3	58.9	.88	2.40	.25	.07	.04	<.01	.08	88.	65.	1.	ND	<1.	97.1	3.4	100.1	100.2
153-83	1847.0-1857.0	46.7	53.5	4.65	7.39	.30	.17	.04	<.01	.66	104.	105.	<1.	ND	<1.	88.2	10.5	98.9	99.6
153-84	1857.0-1867.0	51.5	58.1	1.89	5.10	.30	.04	.02	<.01	.11	101.	54.	<1.	ND	<1.	95.8	7.2	102.3	102.4
153-85	1867.0-1877.0	46.7	58.7	1.09	2.24	.29	.07	.17	<.01	.77	179.	30.	2.	ND	<1.	96.7	3.2	99.7	100.5
153-86	1877.0-1888.1	46.9	58.4	2.54	3.21	.14	.03	.04	.06	.18	135.	35.	<1.	ND	<1.	96.2	4.6	101.3	101.4
153-87	1888.1-1895.6	27.3	30.0	22.50	36.12	.32	.09	.02	.04	29.95	100.	1100.	1.	194.	<1.	49.4	51.3	101.7	131.7
153-88	1908.5-1918.5	50.2	59.1	.74	1.74	.13	.06	.04	.03	.33	103.	<5.	1.	ND	<1.	97.4	2.5	99.7	100.0
153-89	1918.5-1928.5	50.8	59.0	1.78	2.63	.30	.04	.02	.03	.26	82.	50.	1.	ND	<1.	97.2	3.7	101.1	101.3
153-90	1928.5-1938.5	47.3	56.5	2.91	4.51	.16	.09	.02	.03	.55	111.	123.	1.	ND	<1.	93.2	6.4	99.8	100.3
153-91	1938.5-1948.5	45.1	54.7	4.00	6.88	.19	.08	.02	<.01	1.69	74.	143.	2.	ND	<1.	90.1	9.8	99.8	101.5
153-92	1948.5-1958.5	48.4	54.0	4.22	7.54	.14	.09	.02	.02	1.50	82.	152.	2.	ND	<1.	88.9	10.7	99.5	101.0
153-93	1958.5-1968.5	48.1	53.4	4.87	8.01	.11	.06	.06	<.01	2.71	74.	133.	2.	ND	<1.	88.0	11.4	99.6	102.3
153-94	1968.5-1978.5	48.4	52.9	4.24	7.38	.19	.05	.02	<.01	2.07	70.	154.	2.	ND	<1.	87.2	10.5	97.6	99.7
153-95	1978.5-1988.5	48.0	51.3	4.30	11.83	.49	.04	.03	<.01	5.03	37.	135.	2.	ND	<1.	84.5	16.8	99.4	104.5
153-96	1988.5-1998.5	46.7	52.7	4.32	8.88	.52	.04	.03	.03	4.50	8.	285.	2.	ND	<1.	86.9	12.6	98.8	103.3
153-97	1998.5-2008.5	50.4	55.9	2.90	5.28	.33	.05	.04	<.01	1.91	66.	82.	<1.	ND	<1.	92.1	7.5	99.5	101.4
153-98	2008.5-2018.5	50.6	56.4	2.43	4.54	.25	.05	.03	<.01	1.07	26.	90.	<1.	ND	<1.	92.9	6.4	99.2	100.2
153-99	2018.5-2027.2	49.1	55.9	2.76	3.97	.25	.06	.04	<.01	1.48	103.	94.	<1.	ND	<1.	92.1	5.6	98.1	99.6
153SS1	1825.5- 0.0	51.7	59.3	.80	1.40	.23	.04	.05	<.01	.10	116.	110.	1.	ND	<1.	97.7	2.0	99.7	99.8
153SS2	1825.6- 0.0	51.0	59.0	.59	1.06	.29	.09	.06	.08	1.01	79.	17.	1.	ND	<1.	97.3	1.5	98.7	99.8
153SS3	1030.5- 0.0	31.6	36.3	.50	.75	.07	1.21	.43	1.59	37.71	58.	13.	25.	88.	1.	59.8	1.1	60.9	98.6
153SS4	2236.0- 0.0	.5	0.0	41.10	70.80	.13	.15	.05	.07	93.19	21.	2250.	2.	245.	<1.	0.0	100.5	100.3	193.5
153SS5	2040.5- 0.0	52.3	60.5	.35	.19	.20	.04	.03	<.01	.10	102.	5.	1.	ND	<1.	99.7	.3	100.2	100.3
HC-SS1	995.0- 0.0	49.4	60.2	.30	.44	.20	.03	.07	.04	.17	71.	455.	1.	115.	<1.	99.2	.6	99.8	100.0

SHUBENACADIE-STEWIACKE DEPOSIT - HANTS-COLCHESTER AREA   Chemical analyses drillholes 153-1 and SB-1

SAMPLE	INTERVAL (FEET)	PERCENTAGE									PARTS PER MILLION					MINERALS		TOTALS	
		NA2O	CL	CAO	SO4	CO2	MGO	K2O	FE2O3	INSOL	BR	SR	RB	B	U2O3	NACL FROM CL	CASO4 FROM SO4	WITHOUT INSOL	WITH INSOL
SB 1AB	1146.0-1156.0	50.0	57.2	2.05	3.20	.16	.53	.04	.04	.71	71.	85.	1.	ND	<1.	94.3	4.5	99.0	99.7
SB 1CD	1156.0-1167.0	51.1	58.2	1.97	3.51	.22	.04	.05	.04	.42	114.	58.	1.	ND	<1.	95.9	5.0	100.9	101.3
SB 2AB	1167.0-1177.0	47.5	56.4	2.65	4.50	.34	.04	.04	<.01	.26	92.	50.	1.	ND	<1.	93.0	6.4	99.4	99.7
SB 2CD	1177.0-1187.3	39.0	49.9	5.94	12.28	.41	.14	.03	.03	1.69	132.	205.	1.	ND	<1.	82.2	17.4	98.7	100.4
SB 3AB	1308.7-1318.7	42.9	56.3	2.86	4.66	.22	.04	.05	.01	.53	137.	155.	1.	ND	<1.	92.7	6.6	99.4	100.0
SB 3C	1318.7-1325.5	42.4	55.6	3.22	5.77	.43	.10	.20	.05	1.03	53.	123.	1.	ND	<1.	91.5	8.2	99.6	100.7
SB 4	1328.2-1339.0	42.0	52.9	3.85	7.89	.29	.15	.04	.03	2.04	100.	180.	1.	ND	<1.	87.2	11.2	97.8	99.9
SB 5AB	1597.5-1608.0	43.2	54.3	2.18	3.73	.23	.28	.05	.36	5.04	103.	75.	3.	ND	<1.	89.5	5.3	94.8	99.8
SB 5CD	1608.0-1618.0	47.8	54.3	1.55	3.53	.40	.17	.11	.46	5.10	134.	270.	10.	85.	<1.	89.5	5.0	94.2	99.3
SB 6AB	1618.0-1628.0	48.9	53.5	1.63	2.94	.18	.30	.21	.35	6.64	69.	110.	3.	45.	<1.	88.2	4.2	92.3	99.0
SB 6CD	1628.0-1638.0	49.8	56.3	1.63	2.49	.23	.14	.10	.14	2.86	105.	100.	2.	ND	<1.	92.7	3.5	96.4	99.2
SB 7	1638.0-1648.0	43.7	51.2	1.94	2.94	.26	.46	.24	.51	10.53	112.	109.	10.	<45.	<1.	84.4	4.2	88.8	99.3
SB 8	1648.0-1658.0	46.6	54.0	3.16	5.54	.18	.15	.10	.14	3.35	126.	110.	10.	ND	<1.	89.0	7.9	96.8	100.1
SB 9	1658.0-1668.0	51.4	57.1	1.54	2.74	.50	.11	.13	.13	1.97	112.	95.	1.	ND	<1.	94.0	3.9	97.9	99.9
SB10	1668.0-1678.0	47.7	54.6	2.51	4.66	.51	.16	.09	.12	3.15	110.	85.	1.	ND	<1.	90.0	6.6	96.5	99.6
SB11	1678.0-1688.0	46.6	53.4	3.34	5.32	.88	.25	.05	.13	2.85	66.	105.	2.	ND	<1.	88.0	7.6	95.7	98.5
SB12	1688.0-1698.0	49.5	58.1	.92	1.81	.34	.10	.09	.11	1.17	107.	30.	2.	ND	<1.	95.7	2.6	98.2	99.3
SB13	1698.0-1708.0	51.4	55.8	2.33	3.71	.34	.14	.09	.12	2.21	129.	480.	1.	ND	<1.	92.0	5.3	97.4	99.6
SB14	1708.0-1718.0	49.4	56.4	1.76	2.76	.37	.14	.13	.12	2.40	99.	57.	1.	ND	<1.	93.0	3.9	97.0	99.4
SB15	1718.0-1728.0	46.3	51.4	4.86	9.10	.20	.15	.08	.14	2.89	121.	115.	1.	ND	<1.	84.7	12.9	97.3	100.2
SB16	1728.0-1738.0	42.5	48.1	8.00	14.52	.46	.12	.04	.04	7.38	102.	240.	1.	ND	<1.	79.3	20.6	99.6	107.0
SB17	1738.0-1748.0	49.5	55.0	3.09	5.12	.31	.15	.08	.10	1.92	113.	90.	1.	ND	<1.	90.6	7.3	97.9	99.8
SB18	1748.0-1758.0	49.9	55.4	2.10	2.55	.38	.32	.10	.14	4.18	107.	82.	1.	ND	<1.	91.3	3.6	95.4	99.5
SB19	1758.0-1768.0	50.9	57.7	1.44	2.39	.22	.10	.05	.07	1.21	107.	50.	1.	ND	<1.	95.1	3.4	98.5	99.7
SB20	1768.0-1778.0	48.2	55.3	2.96	5.16	.22	.11	.08	.06	1.16	107.	100.	1.	ND	<1.	91.1	7.3	98.4	99.6
SB21	1778.0-1788.0	48.7	54.9	2.55	4.58	.10	.18	.08	.13	2.88	123.	205.	3.	95.	<1.	90.4	6.5	96.8	99.7
SB22A	1788.0-1795.7	50.5	57.7	1.29	2.13	.11	.10	.09	.07	1.42	121.	44.	2.	ND	<1.	95.1	3.0	98.2	99.6
SB23	1805.3-1815.3	39.3	46.1	6.77	13.55	.30	.43	.15	.26	6.46	129.	205.	8.	180.	<1.	76.0	19.2	94.4	100.8
SB24	1815.3-1825.3	48.6	53.9	2.90	5.27	.33	.33	.10	.18	3.69	113.	125.	6.	100.	<1.	88.8	7.5	96.1	99.8
SB25	1825.3-1835.3	40.6	44.5	9.99	17.00	.41	.21	.05	.11	7.99	102.	270.	3.	45.	<1.	73.3	24.1	97.5	105.5
SB26	1835.3-1845.3	40.6	45.7	9.76	16.82	.32	.19	.06	.07	4.95	94.	310.	2.	55.	<1.	75.4	23.9	99.2	104.1
SB27	1845.3-1855.3	44.3	49.4	6.51	12.61	.47	.15	.05	.09	3.09	88.	200.	1.	<45.	<1.	81.4	17.9	98.7	101.8
SB28	1855.3-1865.3	52.6	58.5	1.20	1.94	.19	.05	.08	<.01	.42	96.	40.	1.	ND	<1.	96.4	2.8	99.2	99.6
SB29	1865.3-1876.6	48.3	55.7	2.62	5.07	.28	.07	.23	.05	.99	85.	80.	1.	ND	<1.	91.8	7.2	98.8	99.8
SB30	1880.7-1890.7	40.5	46.3	7.14	14.28	.17	.32	.13	.19	6.26	110.	280.	2.	245.	<1.	76.2	20.3	95.6	101.9

SHUBENACADIE-STEWIACKE DEPOSIT - HANTS-COLCHESTER AREA **Chemical analyses drillholes 153-1 and SB-1**

SAMPLE	INTERVAL (FEET)	PERCENTAGE									PARTS PER MILLION					MINERALS		TOTALS	
		NA2O	CL	CAO	SO4	CO2	MGO	K2O	FE2O3	INSOL	BR	SR	RB	B	U2O3	NACL FROM CL	CASO4 FROM SO4	WITHOUT INSOL	WITH INSOL
SB31	1890.7-1900.7	43.5	50.0	5.75	11.04	.24	.22	.10	.16	3.03	115.	225.	2.	85.	<1.	82.4	15.7	97.5	100.6
SB32	1900.7-1910.7	46.9	54.9	3.16	4.78	.16	.13	.09	.06	1.70	143.	68.	1.	<45.	<1.	90.4	6.8	97.5	99.2
SB33	1910.7-1920.7	32.9	37.2	14.77	27.18	.29	.17	.06	.06	9.80	60.	500.	1.	120.	<1.	61.3	38.6	99.1	108.9
SB34	1920.7-1930.7	42.0	48.9	7.38	14.48	.21	.13	.07	.15	1.94	69.	340.	1.	90.	<1.	80.5	20.6	100.3	102.2
SB35	1930.7-1340.7	41.5	48.2	7.67	13.81	.32	.13	.05	.07	1.08	82.	265.	1.	ND	<1.	79.4	19.6	98.8	99.8
SB36	1940.7-1950.7	47.8	56.0	2.44	4.61	.10	.07	.04	.04	.80	79.	100.	1.	ND	<1.	92.3	6.5	98.7	99.5
SB37	1950.7-1960.7	45.5	52.8	4.75	8.27	.26	.07	.03	.03	.29	60.	155.	1.	ND	<1.	86.9	11.7	98.6	98.9
SB38	1960.7-1970.7	48.7	56.5	1.81	3.39	.22	.08	.07	.03	1.07	77.	95.	1.	ND	<1.	93.2	4.8	97.9	98.9
SB39A	1970.7-1976.5	39.6	46.2	9.84	16.96	.08	.08	.03	.01	.78	69.	235.	1.	ND	<1.	76.1	24.1	100.1	100.9
SB40	1982.2-1992.2	46.6	54.1	4.30	7.40	.31	.08	.04	.05	.99	74.	130.	1.	ND	<1.	89.2	10.5	99.6	100.6
SB41	1993.5-2003.5	50.2	57.2	2.18	2.98	.12	.08	.03	.04	.35	90.	160.	1.	70.	<1.	94.2	4.2	98.7	99.1
SB42	2003.5-2013.5	51.5	58.7	.71	1.40	.37	.07	.04	.03	.77	77.	38.	1.	ND	<1.	96.7	2.0	98.6	99.4
SB43	2013.5-2023.5	46.8	57.5	1.95	3.48	.09	.06	.04	<.01	.39	88.	115.	1.	ND	<1.	94.8	4.9	99.6	100.0
SB44	2023.5-2033.5	45.5	57.2	2.45	4.05	.22	.05	.04	.03	.36	90.	60.	1.	ND	<1.	94.3	5.8	100.1	100.5
SB45	2033.5-2043.5	41.0	51.6	4.96	9.43	.11	.13	.06	.08	2.42	78.	175.	1.	ND	<1.	85.0	13.4	98.0	100.4
SB46	2043.5-2053.5	47.7	59.1	.58	1.31	.18	.06	.07	.07	.84	102.	30.	1.	ND	<1.	97.4	1.9	99.2	100.0
SB47A	2053.5-2061.5	38.0	49.6	7.50	13.59	.19	.05	.03	.05	3.57	102.	235.	1.	ND	<1.	81.7	19.3	100.7	104.3
SB48	2077.5-2087.5	55.8	59.2	.42	1.53	.26	.04	.05	.03	.43	88.	38.	1.	ND	<1.	97.6	2.2	99.5	99.9
SB49	2087.5-2097.5	54.4	60.0	.40	.97	.08	.04	.03	.03	.33	93.	16.	1.	ND	<1.	98.8	1.4	100.0	100.4
SB50	2097.5-2107.5	53.4	59.6	.38	.74	.07	.03	.04	<.01	.20	132.	5.	1.	ND	<1.	98.3	1.1	99.3	99.5
SB51	2107.5-2117.5	44.7	50.2	3.67	11.80	.09	.06	.04	.04	7.55	58.	1000.	1.	ND	<1.	82.7	16.8	97.2	104.7
SB52	2117.5-2127.5	51.2	54.5	3.72	6.79	.20	.04	.03	.03	.29	58.	165.	1.	ND	<1.	89.8	9.6	99.3	99.6
SB53	2127.5-2137.5	52.2	57.6	6.13	3.20	.07	.05	.02	.02	.20	44.	55.	1.	ND	<1.	95.0	4.5	102.6	102.8
SB54	2137.5-2147.5	47.4	51.9	6.08	10.30	.23	.07	.03	.04	.61	44.	215.	1.	ND	<1.	85.5	14.6	100.2	100.8
SB55	2147.5-2157.5	45.6	51.1	6.17	11.15	.12	.05	.03	.04	.97	66.	250.	1.	ND	<1.	84.2	15.8	99.8	100.8
SB56	2157.5-2167.5	45.3	50.4	6.35	9.59	.18	.13	.11	.30	3.98	85.	105.	1.	ND	<1.	83.1	13.6	97.2	101.2
SB57	2167.5-2177.5	40.6	46.7	8.53	13.64	.19	.17	.16	.29	4.60	66.	560.	3.	ND	<1.	77.0	19.4	96.8	101.4
SB58	2177.5-2187.5	24.2	27.9	6.68	10.20	.13	.96	1.16	3.68	36.66	71.	495.	41.	240.	2.	46.0	14.5	61.0	97.7
SB59	2187.5-2194.7	36.7	41.1	2.66	4.21	.25	.57	.96	1.61	24.23	104.	185.	39.	220.	<1.	67.8	6.0	73.9	98.1
SB60	2194.7-2204.0	40.9	48.3	3.31	6.10	.23	.27	.41	.64	11.13	132.	110.	11.	100.	2.	79.6	8.7	88.1	99.2
SB61	2214.0-2223.0	32.0	38.9	5.51	7.93	.23	.54	.90	1.65	23.28	129.	290.	37.	300.	1.	64.1	11.3	76.0	99.3
SB62	2223.0-2235.3	42.1	46.7	7.68	13.50	.13	.18	.17	.29	4.12	148.	400.	3.	60.	<1.	76.9	19.2	96.0	100.1
SB63	2235.3-2245.5	49.9	57.1	2.08	3.45	.23	.05	.05	.05	.39	173.	105.	1.	ND	<1.	94.0	4.9	99.0	99.4
SB64	2245.5-2255.5	42.3	52.0	5.45	8.65	.14	.17	.12	.16	1.98	167.	275.	1.	ND	<1.	85.8	12.3	98.3	100.3
SB65	2255.5-2262.4	43.9	52.0	5.44	9.33	.14	.11	.04	.25	1.19	85.	285.	1.	ND	<1.	85.7	13.2	98.9	100.1

SHUBENACADIE-STEWIACKE DEPOSIT - HANTS-COLCHESTER AREA Chemical analyses drillholes 153-1 and SB-1

SAMPLE	INTERVAL (FEET)	PERCENTAGE									PARTS PER MILLION					MINERALS		TOTALS	
		NA2O	CL	CAO	SO4	CO2	MGO	K2O	FE2O3	INSOL	BR	SR	RB	B	U2O3	NACL FROM CL	CASO4 FROM SO4	WITHOUT INSOL	WITH INSOL
SB66	2271.8-2281.8	48.7	57.6	2.22	2.77	.14	.05	.04	<.01	.79	69.	135.	1.	ND	<1.	94.9	3.9	99.3	100.1
SB67	2281.8-2291.8	49.9	57.7	2.14	3.14	.30	.05	.04	<.01	1.29	60.	54.	1.	ND	<1.	95.1	4.5	99.7	101.0
SB68	2291.8-2301.8	51.5	57.3	1.82	3.14	.32	.05	.02	<.01	.26	66.	40.	1.	ND	<1.	94.3	4.5	98.8	99.0
SB69	2301.8-2311.8	52.8	57.5	1.77	2.81	.64	.05	.03	<.01	.22	47.	100.	1.	ND	<1.	94.8	4.0	98.8	99.1
SB70	2311.8-2321.8	50.7	58.0	2.24	3.09	.26	.13	.03	<.01	.22	41.	90.	1.	ND	<1.	95.6	4.4	100.3	100.5
SB71	2321.8-2331.8	50.2	57.6	1.55	3.21	.07	.06	.02	<.01	.23	36.	95.	1.	ND	<1.	94.9	4.6	99.3	99.5
SB72	2331.8-2341.8	48.6	57.6	2.04	2.37	.37	.04	.02	<.01	.41	47.	92.	1.	ND	<1.	94.9	3.4	98.7	99.1
SB73	2341.8-2351.8	48.5	56.9	2.19	4.36	.34	.03	.03	<.01	.30	44.	103.	1.	ND	<1.	93.7	6.2	99.6	99.9
SB74	2351.8-2361.8	51.0	56.8	2.26	3.68	.82	.04	.02	<.01	.88	49.	120.	<1.	ND	<1.	93.6	5.2	98.9	99.8
SB75	2361.8-2371.8	49.8	58.4	1.50	2.22	.48	.04	.02	.01	.35	36.	60.	1.	ND	<1.	96.3	3.2	99.6	99.9
SB76	2371.8-2381.8	47.0	56.7	2.38	3.50	.40	.04	.03	.01	.72	38.	95.	1.	ND	<1.	93.5	5.0	98.7	99.4
SB77	2381.8-2391.8	49.0	55.4	4.13	4.67	.77	.03	.02	.03	1.22	36.	105.	1.	ND	<1.	91.3	6.6	98.9	100.2
SB78	2391.8-2401.8	49.0	56.6	2.87	4.04	.53	.04	.03	<.01	.90	30.	120.	1.	ND	<1.	93.2	5.7	99.3	100.2
SB79	2401.8-2411.8	49.1	54.3	4.81	7.45	.50	.04	.02	<.01	2.25	38.	135.	1.	ND	<1.	89.5	10.6	100.4	102.7
SB80	2411.8-2421.8	47.7	53.5	4.75	7.64	.52	.03	.03	.03	2.11	47.	185.	1.	ND	<1.	88.2	10.8	99.3	101.4
SB81	2421.8-2422.8	47.2	55.3	3.94	6.14	.69	.03	.01	<.01	1.76	69.	185.	1.	ND	<1.	91.1	8.7	100.1	101.9
SB82	2431.8-2441.8	47.2	54.9	4.75	5.82	.68	.04	.02	<.01	2.44	30.	975.	1.	ND	<1.	90.4	8.3	99.7	102.1
SB83	2441.8-2451.8	47.5	53.8	4.38	6.36	.67	.03	.04	<.01	3.55	27.	275.	1.	ND	<1.	88.6	9.0	98.1	101.7
SB84	2451.8-2461.8	50.0	56.1	3.19	4.06	.57	.04	.03	<.01	1.62	52.	160.	1.	ND	<1.	92.4	5.8	98.7	100.3
SB85	2461.8-2471.8	52.5	57.0	2.42	3.36	.54	.03	.03	<.01	1.09	58.	115.	1.	ND	<1.	93.9	4.8	99.0	100.1
SB86	2471.8-2481.8	47.4	55.7	3.33	4.44	.51	.04	.03	<.01	1.78	52.	125.	1.	ND	<1.	91.7	6.3	98.6	100.3
SB87	2481.8-2490.2	43.8	51.1	6.67	10.33	.50	.09	.03	.02	4.27	77.	160.	1.	ND	<1.	84.2	14.7	99.3	103.6
SBSS1	2083.0- 0.0	51.6	59.3	.56	1.00	.28	.03	.04	.04	.14	114.	5.	3.	ND	<1.	97.7	1.4	99.1	99.2
SBSS2	2083.1- 0.0	51.4	58.9	.56	1.18	.41	.08	.06	.07	.77	132.	15.	1.	ND	<1.	97.1	1.7	98.6	99.4
SBSS3	1855.5- 0.0	51.4	59.1	.37	.61	.32	.11	.06	.07	1.43	211.	5.	3.	ND	<1.	97.4	.9	98.3	99.7
SBSS4	2495.0- 0.0	.9	1.6	39.79	70.32	.84	.58	.04	<.01	69.65	34.	15.	3.	ND	<1.	2.6	99.9	101.5	171.1

MALAGASH DEPOSIT-CUMBERLAND AREA

Table 4-2. Analyses of upper 17 feet of Malagash Mine salt body*
(after Ellsworth, 1926)

Component	Samples		
A. Part soluble in hot water	1 (Per cent)	2 (Per cent)	3 (Per Cent)
Sodium (Na)	38.57	23.15	37.42
Potassium (K)	0.17	0.16	0.14
Calcium (Ca)	0.18	0.81	0.31
Magnesium (Mg)	0.01	0.06	0.03
Chlorine (Cl)	59.58	35.85	57.85
Sulphuric acid (SO_4)	0.64	3.05	1.07
Iodine (I)	none	none	none
Bromine (Br)	none	none	none
Subtotal	99.15	63.08	96.82
B. Part insoluble in hot water			
Silica (SiO_2)	0.61	21.85	1.60
Ferric oxide and alumine (Fe_2O_3 and Al_2O_3)	0.31	7.90	0.77
Lime (CaO)	0.06	0.25	0.06
Magnesia (MgO)	0.07	2.15	0.19
Soda (Na_2O)	-	0.93	0.09
Potash (K_2O)	-	trace	
Sulphuric anhydrite (SO_3)	0.10	0.22	
Organic (combustible matter)	0.25	2.06	0.30
Subtotal	1.40	35.36	3.01
Total	100.55	98.44	99.83

Sample 1: 16 feet to 17 feet depth
Sample 2: 8 feet to 16 feet depth
Sample 3: top of salt to 8 feet depth

Analyses of a sample
evidently from the potash zone**

Component	Per cent
Na	33.55
K	4.58
Cl	59.20
CaO	0.21
SO_3	0.30
Mg	0.08
Insoluble	0.35
Water	0.13

Hypothetical composition

Component	Per Cent
NaCl	90.38
KCl	8.80
$MgCl_2$	0.19
$CaSO_4$	0.49

Average analyses of salt bed
worked during 1926***

Component	Per cent
Insoluble in water	0.36
Iron oxide and alumina	traces
Calcium sulphate	0.401
Calcium chloride	0.118
Magnesium chloride	0.026
Sodium chloride	99.095

Analysis of selected pure white salt
marketed as table and grocery salt, 1926***

Component	Per cent
Insoluble in water	0.04
Iron oxide and alumina	traces
Calcium sulphate	0.24
Magnesium sulphate	0.30
Sodium sulphate	0.0
Sodium chloride	99.63

*Sampled by A. O. Hayes (1920). Analyst, S. W. Baridon, Mines Branch, Departmentof Mines, Ottawa, Ontario **Analyst, H. C. Rickaby ***Analyst, Commercial

MALAGASH DEPOSIT–CUMBERLAND AREA

Table 4-3. Analyses of samples representing channel sampling foot by foot, normal to dip of strata*

Series	KCl	K_2O equivalent	H_2O insoluble after ignition	Total H_2O	KCl on soluble salt basis	K_2O on soluble salt basis
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
A 1	2.67	1.69	2.94	0.49	2.76	1.75
2	6.31	3.99	2.04	0.31	6.46	4.08
3	2.41	1.52	0.95	0.17	2.44	1.54
4	6.32	4.00	2.10	0.34	6.48	4.10
5	0.85	0.53	10.98	1.20	0.97	0.60
6	1.16	0.73	13.69	1.27	1.36	0.86
Average	3.29	2.08	5.45	0.63	3.41	2.15
D 1	1.01	0.64	15.79	1.94	1.23	0.78
2	0.89	0.56	11.03	1.79	1.02	0.64
3	0.74	0.47	7.53	1.13	0.81	0.51
4	1.22	0.77	10.47	1.98	1.39	0.84
5	0.92	0.58	6.25	1.15	0.98	0.62
6	0.63	0.40	4.65	1.03	0.67	0.42
Average	0.90	0.57	9.29	1.50	1.01	0.63
E 1	0.66	0.42	3.06	0.51	0.68	0.43
2	0.81	0.51	3.71	0.57	0.84	0.53
3	4.32	2.73	2.55	0.27	4.44	2.81
4	3.53	2.23	1.32	0.24	3.58	2.27
5	2.66	1.68	1.29	0.34	2.70	1.71
6	1.21	0.76	11.36	1.74	1.39	0.87
7	11.52	7.28	1.04	0.29	11.67	7.37
Average of 1 to 6	2.19	1.39	3.88	0.61	2.27	1.44

Note: H_2O insoluble weighed after ignition; hence results are appreciably low due to loss of water and combustion of considerable organic matter.

*Analyst, H. V. Ellsworth (1926, Table 1)

Table 4-4 Composite average of series A samples*

Component	Per Cent
Salts readily soluble in water	93.56
Insoluble, washed Cl free, but containing anhydrite	6.44

Part soluble in water	Per cent	Part insoluble in water	Per cent
Na (diff.)	37.12	SiO_2 (total)	57.11
K	1.66	SiO_2 (combined)	23
K_2O	2.00	SiO_2 (uncombined**)	54
KCl	3.16	Fe_2O_3	4.75
Ca	0.47	FeO	-
Mg	0.02	Al_2O_3	13.18
Fe	ND	TiO_2	0.69
Al	ND	MnO	0.06
Cl	59.207	Cr_2O_3***	0.08
Br	0.03	V_2O_3	ND
I	ND	CaO	3.30
SO_4	1.04	MgO	6.50
CO_3	trace	K_2O	1.83
B_2O_3	ND	Na_2O	0.18
H_2O	0.45	SO_3	4.15
Total	100.00	CO_2	1.32
		P_2O_5	0.10
		B_2O_3	ND
		Cl	0.03
		H_2S	trace
		Co, Ni	ND
		Carbon	1.09
		H_2O(-110°)	0.71
		H_2O(+110°)	4.04
		Total	99.12

Calculated combinations

Component	Per cent
NaCl	94.91
KCl	3.16
$CaSO_4$	1.47
$CaCl_2$	0.11
$MgCl_2$	0.08
NaBr	0.05
H_2O	0.45
Total	100.23

Insoluble residue:
Calculated approximate
mineral composition

Component	Per cent
Quartz crystals and free silica	33-34
Silicates	45-46
Anhydrite	7.06
Hematite	4
Carbonates	2.6
Water	4.75
Carbon	1.09

Calculated approximate mineral composition
of series A samples as a whole

Component	Per cent
NaCl	8.79
KCl	2.96
$CaSO_4$	1.82
$CaCl_2$	0.09
$MgCl_2$	0.07
NaBr	0.04
Quartz and free silica	2.2
Silicates of Al,Mg,K,Fe,Ti, etc.	2.9
Carbonates (Mg or other)	0.17
Hematite	0.25
Carbon	0.06
H_2O	0.72
Total	100.07

ND = not detected

*Analyst, H. V. Ellsworth (1926); one hundred grams each of the ground series A samples were mixed together and used for a more complete average analyses

**quartz crystals and silica possibly of organic origin

***verified by duplicate determinations; possibly from blasting powder

Average of Series B samples*

Component			Per cent
Salts readily soluble in water			97.99
Insoluble, washed Cl free but containing anhydrite			2.10
Part soluble in water		**Part insoluble in water**	
Component	Per cent	Component	Per cent
Na (diff.)	37.48	SiO_2 (total)	43.78
K	1.85	Al_2O_3	11.78
K_2O	2.23	Fe_2O_3	2.99
KCl	3.51	TiO_2	0.62
Ca	0.21	MnO	0.06
Mg	0.006	CaO	10.85
Fe	ND	MgO	5.96
Al	ND	K_2O	1.68
Cl	59.64	Na_2O	0.12
Br	0.0005	SO_3	14.36
SO_4	0.49	CO_2	1.28
CO_3	trace	H_2O	4.31
H_2O	0.32	Carbon	present
Total	100.00	Total	97.79

Calculated Approximate Mineral Composition

Component	Per cent
Quartz crystals and and free silica	20-22
Silicates	41-43
Anhydrite	24-42
Carbonates	2.5
Hematite	2
Carbon	1-2
Water	4.31

*Analyst, H. V. Ellsworth (1926)   ND = not detected

Calculated Combinations

Component	Per cent
NaCl	95.57
KCl	3.51
$CaSO_4$	0.71
$CaCl_2$	trace
$MgCl_2$	0.02
NaBr	0.006
H_2O	0.45
Total	100.26

Calculated approximate mineral composition of Series B samples as a whole

Component	Per cent
NaCl	93.56
KCl	3.44
$CaSO_4$	1.20
$CaCl_2$	trace
$MgCl_2$	0.02
NaBr	0.006
Quartz crystals and free silica	0.45
Silicates	0.88
Carbonates	0.04
Hematite	0.04
Carbon	0.02
Water	0.54
Total	100.19

Average of Series C samples

Component			Per cent
Salts readily soluble in water			97.23
Insoluble, washed Cl free but containing anhydrite			2.77
Part soluble in water		Part insoluble in water	
Component	Per cent	Component	Per cent
Na (diff.)	38.60	SiO_2	47.43
K	0.27	Al_2O_3	13.04
K_2O	0.33	Fe_2O_3	4.49
KCl	0.52	TiO_2	0.66
Ca	0.27	MnO	0.10
Mg	0.013	CaO	8.02
Fe	none	MgO	5.98
Al	none	K_2O	2.16
Cl	59.98	Na_2O	0.23
Br	0.020	SO_3	11.17
I	ND	CO_2	1.03
SO_4	0.61	H_2O	5.20
CO_3	trace	Carbon	present
H_2O	0.23		
Total	100.00	Total	99.51

Calculated Combinations

Component	Per cent
NaCl	98.47
KCl	0.52
$CaSO_4$	0.86
$CaCl_2$	0.06
$MgCl_2$	0.05
NaBr	0.02
H_2O	0.23
Total	100.21

Calculated Approximate Mineral Composition

Component	Per cent
Quartz crystals and free silica	24-26
Silicates	45-46
Anhydrite	18.99
Carbonates	2
Hematite	4
Carbon	1-2
Water	5.2

Calculated approximate mineral composition of Series C samples as a whole

Component	Per cent
NaCl	95.75
KCl	0.50
$CaSO_4$	1.39
$CaCl_2$	0.05
$MgCl_2$	0.05
NaBr	0.02
Quartz crystals and free silica	0.70
Silicates	1.25
Carbonates	0.05
Hematite	0.11
Carbon	0.03
Water	0.37
Total	100.27

Table 4-4 Average of Series D samples*

Component	Per cent
Water soluble salts	88.89
H_2O insoluble	11.11

Part Soluble in Water

Pure-looking bed of rock salt 4 feet thick, 20 feet north of shaft, almost pure white except for a slight brownish tinge, and nonhygroscopic.

Component	Per cent
Na (diff.)	37.57
K	0.49
K_2O	0.59
KCl	0.93
Ca	0.65
Mg	0.095
Fe	None
Al	None
Cl	58.93
Br	0.015
I	None
SO_4	1.39
H_2O	0.46
Total	100.00

Component	Per cent
Na(diff.)	38.55
K	0.43
Ca	0.20
Mg	0.001
Fe	None
Al H_4O soluble	None
Cl	59.78
Br	0.019
SO_4	0.47
H_2O	0.07
Insoluble	0.48
Total	100.00

Selected Pale Yellowish Sylvite from Lens E7 in Malagash Mine.
Calculated Combinations

Component	Per cent
KCl	92.89
NaCl	6.48
Ca	0.02
Mg	0.008
Fe (H_2O soluble)	None
Al (H_2O soluble)	None
Br	0.096
I	None
SO_4	0.03
H_2O	0.29
Insoluble	0.12
Total	99.94

Component	Per cent
	97.91
NaCl	0.82
KCl	0.67
$CaSO_4$	None
$CaCl_2$	0.004
$MgCl_2$	0.024
NaBr	0.07
H_2O	0.48
Insoluble	
Total	99.97

*Analyst, H. V. Ellsworth, 1926

MALAGASH DEPOSIT - CUMBERLAND AREA

Malagash No. 1 Core samples (1 foot every 5 feet), analyses reported in per cent

Interval (ft.)	Sample Number	Moisture LOI	K (sol.)	K (total)	Insoluble	Na	Cl	Ca	Mg	SO_4
700-701	S821/1	5.90	0.008		90.9	0.15	0.13	0.18	0.018	0.85
705-706	2	6.35	0.008		91.7	0.16	0.15	0.10	0.009	0.49
710-711	3	7.27	0.006		88.0	0.18	0.20	0.29	0.018	1.01
715-716	4	7.11	0.006		90.7	0.19	0.23	0.11	0.029	0.54
720-721	5	7.75	0.003	1.20	85.4	0.09	0.08	0.58	0.009	1.53
725-726	6	8.49	0.008	3.40	86.7	0.22	0.28	0.30	0.014	1.01
730-731	7	5.80	0.004	2.80	92.5	0.18	0.23	0.07	0.024	0.41
735-736	8	20.71	0.001*	0.06	66.6	0.003	0.02	1.14	0.029	2.79
740-741	9	20.70	0.001*	0.05	75.1	0.005	0.04	1.18	0.009	2.87
745-746	10	20.73	0.001*	0.07	66.1	0.008	0.02	1.17	0.018	2.87
750-751	11	7.85	0.015	2.4	88.9	0.27	0.40	0.21	0.029	0.80
755-756	12	5.01	0.018	2.3	92.4	0.18	0.25	0.13	0.009	0.55
760-761	13	6.48	0.009	2.6	90.5	0.28	0.53	0.10	0.018	0.54
765-766	14	13.34	0.005	0.80	78.5	0.17	0.24	0.94	0.018	2.44
770-771	15	20.76	0.001	0.04	67.1	0.003	0.02	1.19	0.009	2.87
773.5-773.8	16	20.74	0.001	0.05	63.5	0.007	0.02	1.21	0.014	2.93
775-776	17	10.31	0.01	1.30	82.6	0.40	0.63	0.46	0.024	1.33
780-781	18	20.75	0.001*	0.06	66.5	0.009	0.03	1.22	0.018	2.91
785-786	19	20.73	0.001*	0.06	67.2	0.009	0.03	1.20	0.018	2.90
790-791	20	19.40	0.001	0.15	69.1	0.03	0.15	1.22	0.018	2.95
795-796	21	20.49	0.001*	0.05	66.4	0.02	0.04	1.22	0.005	2.94

Malagash No. 1 Selected core sample, analyses reported in per cent

Depth (ft.)	Sample Number	Moisture	LOI	K (sol.)	Insoluble	Na	Cl	Ca	Mg	SO_4
735	S818/11	14.5	6.10	0.01	66.82	0.015	0.11	1.17	0.039	2.89
774	/10	13.2	7.48	0.01**	68.62	0.015	0.21	1.15	0.019	2.81
777	/9	15.6	5.49	0.01**	66.28	0.020	0.39	1.22	0.019	2.89
786	/8	16.4	4.30	0.01	66.52	0.010	0.28	1.20	0.009	2.93
797	/7	15.7	5.95	0.01**	71.54	0.015	0.35	1.03	0.019	2.48
800	/6	4.8	3.63	0.025	86.62	0.435	1.52	0.42	0.004	1.09
803	/5	0.7	3.83	0.035	87.80	0.620	0.84	0.67	0.015	1.84
825	/4	2.3	3.55	0.030	87.59	0.560	0.78	0.26	0.015	0.81
829	/3	3.9	4.07	0.035	84.42	0.850	1.40	0.42	0.029	1.04
835	/2	15.7	4.99	0.01**	66.58	0.010	0.36	0.61	0.37	2.93
854	S818/1	3.0	4.75	0.38	75.85	1.10	2.25	0.61	0.029	1.60

Malagash No. 1 Selected core sample, analyses reported in per cent***

Depth (ft.)	Sample Number	K (sol.)	Insoluble	NaCl	Ca	Mg	SO_4
866	S816/8	0.05	8.87	85.7	0.9	trace	0.80
876	/7	0.07	1.14	97.8	0.1	nil	0.50
890	/6	0.08	21.7	79.4	1.5	nil	0.75
961	/5	0.08	2.19	96.5	0.07	nil	0.20
966	/4	0.06	1.21	97.8	0.23	nil	0.40
996	/3	0.18	1.58	95.3	0.08	nil	0.05
1001	/2	0.21	2.41	97.8	0.07	nil	0.05
1002	S816/1	0.28	1.28	96.5	0.06	nil	nil

*less than 0.001

**Nova Scotia Department of Mines (1966a)

***results on oven dried samples

MALAGASH DEPOSIT - CUMBERLAND AREA

Chemical Analyses Wallace No. 1 core samples,* analyses reported in per cent

Interval (ft.)	Sample Number		Moisture	LOI	K (sol.)	K (total)	Insoluble	Br	NaCl	Ca	Mg	SO_4
	NSDM	Lab										
2870.3-2872	1-1	S1077/6	0.07	0.45	0.07	0.17	3.5	0.0198	94	0.42	.01	1.00
2872-2878	1-2	S1077/4	1.01	2.60	0.14	1.05	35.7	0.0127	54.6	1.44	0.08	3.16
2875-2878	1-3	S1077/5	0.36	1.19	0.05	0.90	13.8	0.0170	82.3	0.77	0.10	1.76
2878-2881	1-4	S1077/2	1.01	3.17	0.07	0.90	37.7	0.0131	53.3	1.31	0.20	2.85
2881-2884	1-5	S1077/3	0.73	2.17	0.12	1.60	27.0	0.0134	65.8	0.94	0.09	2.40
2884-2887	1-6	S1077/1	1.05	2.49	0.08	0.75	28.8	0.0144	64.0	1.28	0.26	2.79
2938-2940.3	1-7	S1077/11	0.02	0.48	1.50	1.60	2.6	0.0213	90.4	0.34	0.06	0.71
2940.3-2942.8	1-8	S1077/9	0.77	1.83	0.20	0.70	18.1	0.0197	74.4	1.02	0.13	2.03
2960.8-2963.3	1-9	S1077/10	0.96	1.92	0.06	0.60	19.8	0.0190	71.4	1.17	0.12	2.36
2965.7-2968.1	1-10	S1077/7	0.81	1.16	0.14	0.55	14.3	0.0185	82.3	0.49	0.14	1.05
3027-3029	1-11	S1077/8	2.84	4.25	0.20	1.10	50.2	0.0190	38.4	1.20	0.25	2.12

Wallace No. 1, analyses reported in per cent

Interval (ft.)	Sample Number		Moisture	LOI	K (sol.)	K (total)	Insoluble	Br	NaCl	Ca	Mg	SO_4
	NSDM	Lab										
2812-2816	1-12	S1081/1	0.23	0.31	0.05	0.50	2.92	0.0185	35.5	0.37	0.021	0.84
2816-2820	1-13	S1081/2	0.24	0.29	0.04	0.50	2.33	0.0175	96.6	0.41	0.018	0.92
2820-2827	1-14	S1081/3	0.16	0.28	0.04	0.50	1.77	0.0169	96.0	0.45	0.018	1.03
2887-2892	1-15	S1081/4	0.67	0.51	0.05	0.55	4.65	0.0203	23.9	0.41	0.070	0.87
2927.5-2932.5	1-16	S1081/5	0.28	0.63	0.04	0.80	9.72	0.0175	87.9	0.49	0.030	1.08
2932.5-2938	1-17	S1081/6	0.15	0.60	0.03	0.60	7.16	0.0180	90.8	0.42	0.018	0.92
2943-2947	1-18	S1081/7	0.72	1.77	0.10	1.00	22.01	0.0179	73.5	0.84	0.070	1.75
2955-2961	1-19	S1081/8	2.26	3.28	0.80	1.75	36.87	0.0192	54.5	0.74	0.076	1.18
2963.5-2966	1-20	S1081/9	1.38	2.55	0.10	1.25	37.66	0.0146	54.5	1.05	0.203	2.07
2971-2975	1-21	S1081/10	0.30	0.35	0.05	0.40	40.08	0.0202	96.0	0.48	0.073	1.10
2975-2980	1-22	S1081/11	1.38	2.88	1.0	1.40	21.91	0.0228	69.4	0.81	0.197	1.44
3382-3387	1-23	S1081/12	1.20	2.02	0.40	1.00	17.60	0.0192	76.1	0.89	0.048	1.45
3387-3391	1-24	S1081/13	0.59	1.28	0.20	0.70	8.89	0.0198	87.9	0.48	0.048	0.90
3391-3394	1-25	S1081/14	0.74	0.64	0.32	0.65	6.40	0.0175	92.5	0.36	0.055	0.73
2980-2984	1-26	S1081/15	0.22	0.33	0.70	0.85	2.82	0.0217	95.0	0.30	0.015	0.69
2991-2994.5	1-27	S1084/1	1.87	3.18	0.10	1.35	37.02	0.0205	55.4	0.84	0.20	1.50
2994-2997	1-28	S1084/2	0.39	1.21	0.08	0.55	12.17	0.0218	86.2	0.47	0.12	0.99
3006-3010	1-29	S1084/3	1.28	3.09	0.12	1.10	38.78	0.0187	54.5	0.92	0.13	1.68
3020-3023	1-30	S1084/4	0.10	0.67	0.06	0.35	5.76	0.0198	92.5	0.46	0.07	1.07
3023-3027	1-31	S1084/5	0.11	0.59	0.06	0.40	3.37	0.0197	94.5	0.45	0.05	0.97
3029-3031	1-32	S1084/6	0.10	0.43	0.06	0.35	2.63	0.0190	96.1	0.39	0.02	0.81
3110-3114	1-33	S1084/7	0.83	1.56	0.08	0.75	12.78	0.0184	82.7	0.48	0.15	0.88
3114-3118	1-34	S1084/8	0.13	0.22	0.05	0.15	2.27	0.0184	96.1	0.36	0.02	0.83
3120-3125	1-35	S1084/9	0.47	1.28	0.04	0.55	13.63	0.0202	82.4	0.57	0.06	1.11
3125-3130	1-36	S1084/10	0.35	1.46	0.04	0.60	14.65	0.0205	82.7	0.47	0.04	0.87
3900-3903	1-37	S1084/11	4.25	9.42	5.20	6.00	28.89	0.0416	40.6	0.88	1.89	0.65
3903-3906	1-38	S1084/12	3.92	14.29	5.76	5.75	36.41	0.0618	22.8	0.88	2.82	0.57
3806-3908	1-39	S1084/13	3.49	9.75	3.42	3.50	24.67	0.0390	50.3	0.80	1.70	0.74
3908-3914	1-40	S1084/14	5.20	12.68	4.50	6.00	33.17	0.0409	32.3	0.88	2.48	0.59

Interval (ft.)	Sample Number		K**	K*** (total)	K*** (sol.)	Na
	NSDM	Lab				
3900-3903	1-37	S1084/11	5.52	5.09		5.9
3903-3906	1-38	S1084/12	5.75			8.9
3906-3908	1-39	S1084/14	3.15	3.45	3.18	19.8
3908-3914	1-40	S1084/14	4.30			12.7

*Analyses by Nova Scotia Research Foundation (Nova Scotia Department of Mines, 1966a).

**Analysis by flame photometry

***Analysis by another lab

Wallace No. 1, analyses reported in per cent

Interval (ft.)	Sample Number		Moisture	LOI	K (sol.)	K (total)	Insoluble	Br	NaCl	Ca	Mg	SO_4
	NSDM	Lab										
3919-3921	1-41	S1092/1	3.64	7.99	4.30	4.74	43.15	0.0496	20.3	1.04	2.43	0.47
3923-3928	1-42	/2	3.35	10.0	2.70	2.75	41.58	0.0542	25.4	1.08	1.58	0.52
3928-3933	1-43	/3	3.81	10.9	4.30	4.70	41.36	0.0433	27.9	1.00	2.50	0.49
3933-3937	1-44	/4	2.96	12.9	2.12	2.33	39.49	0.0360	33.0	1.20	1.31	0.57
3937-3942.5	1-45	/5	3.29	17.4	1.33	1.50	36.51	0.0264	44.4	1.04	0.73	0.63
3942.5-3946	1-46	/6	3.08	15.5	3.20	4.60	35.98	0.0291	39.4	1.80	0.48	0.64
3950-3954	1-47	S1100/1	3.15	6.53	3.70	3.70	40.07	0.0263	40.64	1.08	1.19	0.58
3954-3957	1-48	/2	2.91	5.42	4.70	5.15	34.71	0.0261	44.45	0.98	0.57	0.67
3957-3959	1-49	/3	2.90	5.70	5.60	6.00	34.21	0.0266	42.55	0.90	0.70	0.64
3959-3962	1-50	/4	1.64	4.57	4.05	5.40	27.84	0.0226	53.34	0.96	0.39	0.77
3962-3964	1-51	/5	1.21	3.89	1.00	1.26	27.04	0.0181	48.89	0.88	0.29	0.74
3964-3967	1-52	/6	2.63	5.47	3.80	4.25	34.36	0.0243	47.63	0.92	0.63	0.62
3967-3968.5	1-53	/7	3.65	6.75	6.80	6.80	38.02	0.0309	35.56	0.98	1.00	0.57
3968.5-3971.5	1-54	/8	3.79	7.08	3.00	3.00	40.61	0.0322	29.21	1.10	0.97	0.55
3971.5-3973.5	1-55	/9	0.70	2.33	1.06	1.05	12.53	0.0177	78.10	0.62	0.30	0.76
3973.5-3978	1-56	/10	0.17	0.80	0.38	0.80	4.37	0.0151	86.95	0.46	0.14	0.77
3978-3983	1-57	/11	0.15	1.22	0.53	0.63	5.81	0.0154	90.17	0.64	0.08	0.91
3983-3986	1-58	/12	0.44	1.87	0.60	0.78	10.56	0.0154	78.10	1.06	0.33	1.21
3986-3988	1-59	/13	0.90	3.08	0.96	1.00	20.49	0.0174	69.22	0.96	0.30	0.91
3988-3990	1-60	S1104/1	0.39	1.73	0.59	0.65	8.06	0.0164	83.19	0.68	0.17	0.90
3990-3992	1-61	/2	1.61	4.48	1.24	1.60	29.03	0.0210	58.12	1.24	0.35	0.86
3992-3994	1-62	/3	1.84	4.58	1.12	1.36	28.47	0.0200	58.12	1.20	0.45	0.90
3994-3997	1-63	/4	0.41	1.92	0.58	0.56	10.04	0.0162	80.01	0.64	0.18	0.88
3997-3998.5	1-64	/5	2.33	4.77	1.60	1.55	30.71	0.0231	54.61	1.24	0.61	0.83
3998.5-4001	1-65	/6	2.83	5.48	2.35	2.80	32.46	0.0256	50.80	1.04	0.64	0.65
4001-4003	1-66	/7	2.84	7.00	3.30	3.75	41.02	0.0345	35.56	1.40	0.70	0.60
4003-4005	1-67	/8	2.92	5.52	2.46	2.95	22.08	0.0272	58.56	0.84	0.56	0.83
4005-4008	1-68	/9	1.41	3.17	1.42	2.05	13.25	0.0217	73.03	0.76	0.50	0.80
4008-4010	1-69	/10	0.42	1.91	0.91	1.20	7.79	0.0164	81.28	0.40	0.28	0.66

Interval (ft.)	Sample Number		K*	K** (total)	K*** (sol.)	Na
	NSDM	Lab				
3919-3921	1-41	S1092/11	4.14	4.84	3.43	7.99
3923-3928	1-42	/12	2.84	4.06		10.00
3928-3933	1-43	/13	4.44			10.9
3933-3937	1-44	/14	2.98	2.68		12.9
3937-3942.5	1-45	/15	1.84			17.4
3942.5-3946	1-46	/16	4.30	4.14		15.5

*Analysis by flame photometry
**Analysis by another lab

Sample Number		K (avg.)	NaCl	Mg
NSDM	Lab			
1-118	S1126/49	2.82	71.1	28.0
-119	/50	4.32	64.1	25.25
-120	/51	6.75	63.5	25.0
-121	S1128/1	3.96	73.0	28.75
-122	/2	3.98	71.1	28.0
-123	/3	2.64	74.3	29.25
-124	/4	5.66	55.9	22.0
-125	/5	2.24	83.8	33.0
-126	/6	1.76	87.6	34.5
-127	/7	1.22	85.7	33.75
-128	/8	1.89	78.1	30.75
-129	/9	1.44	74.9	29.5
-130	/10	2.00	72.4	28.5

MALAGASH DEPOSIT-CUMBERLAND AREA
Wallace No. 2, analyses in per cent

Interval (ft.)	Sample Number		Moisture	LOI	K (sol.)	K (total)	Insoluble	Br	NaCl	Ca	Mg	SO_4
	NSDM	Lab										
1303-1305	2-70	S1107/1	0.14	0.67	0.22	0.36	8.05	0.0072	86.36	0.44	0.14	1.04
1305-1307	2-71	/2	0.22	0.81	0.69	0.80	11.59	0.0085	82.55	0.46	0.06	0.85
1307-1310	2-72	/3	0.14	0.93	0.74	0.82	11.78	0.0078	83.82	0.54	0.08	0.88
1310-1312	2-73	/4	0.36	0.92	1.30	1.57	12.58	0.0092	81.53	0.48	0.07	0.80
1312-1314	2-74	/5	0.04	0.67	0.27	0.42	8.66	0.0082	86.36	0.36	0.02	0.61
1322-1325	2-75	/6	0.37	1.72	4.93	5.40	16.04	0.0139	70.49	0.40	0.11	0.63
1335-1337	2-76	/7	1.42	3.92	1.44	2.37	25.67	0.0167	64.77	0.76	0.38	0.96
1339-1341	2-77	/8	0.19	1.09	1.84	2.16	7.61	0.0136	87.00	0.36	0.12	0.73
1344-1346	2-78	/9	0.51	2.10	3.18	3.90	13.13	0.0173	74.93	0.56	0.14	0.72
1350-1352	2-79	/10	1.25	3.73	2.63	2.85	16.64	0.0292	69.85	0.60	0.41	0.76
1365-1367	2-80	/11	0.59	2.18	1.02	1.34	14.82	0.0177	77.47	0.76	0.13	0.95
1372-1376	2-81	/12	1.59	3.91	1.47	1.70	10.95	0.0252	76.84	0.60	0.55	0.69
1379-1381	2-82	/13	1.88	3.85	1.58	1.60	10.39	0.0278	78.11	0.48	0.78	0.72
1384-1386	2-83	/14	1.10	2.56	1.01	1.00	2.22	0.0255	89.15	0.40	0.53	0.74
1386-1388	2-84	/15	1.99	4.04	1.23	1.26	20.17	0.0236	69.23	0.90	0.50	1.01
1390-1393	2-85	/16	0.64	2.39	1.03	1.25	15.86	0.0206	74.93	0.82	0.12	1.06
1421-1423	2-86	/17	1.09	2.73	1.18	1.20	5.91	0.0263	83.82	0.56	0.51	0.90
1428-1430	2-87	/18	2.52	4.24	1.48	1.75	9.69	0.0393	76.20	0.48	0.80	0.78
1436-1438	2-88	/19	2.23	3.91	0.92	1.30	14.61	0.0326	74.30	0.76	0.61	1.11
1442-1446	2-89	/20	4.16	5.84	2.15	2.15	2.24	0.0609	68.58	0.24	1.38	0.49
1446-1449	2-90	/21	6.71	7.63	3.19	4.07	8.72	0.0729	71.12	0.40	1.87	0.71
1456-1459	2-91	/22	3.09	4.54	2.48	2.70	1.63	0.0481	81.25	0.60	1.00	0.63
1459-1462	2-92	/23	1.94	3.11	1.49	1.70	5.35	0.0333	83.82	0.44	0.64	0.78
1473-1475	2-93	/24	1.02	3.85	1.27	1.65	21.24	0.0265	68.50	0.72	0.38	1.04
1488-1491	2-94	/25	0.01	0.77	0.33	0.48	3.36	0.0181	94.62	0.24	0.12	0.50
1491-1493	2-95	/26	0.56	2.29	0.85	1.00	15.88	0.0213	78.11	0.28	0.32	0.47
1509-1513	2-96	/27	2.46	3.99	1.44	1.80	1.54	0.0366	85.09	0.32	0.95	0.74
1518-1521	2-97	/28	1.91	3.14	0.55	1.12	23.22	0.0285	68.50	0.68	0.44	1.12
1527-1530	2-98	/29	5.43	7.67	3.72	4.00	1.65	0.0734	68.58	0.22	1.91	0.57
1530-1532	2-99	/30	5.51	7.72	3.26	4.90	1.85	0.0706	72.39	0.26	1.88	0.57
1534-1536	2-100	/31	3.02	4.84	1.24	2.00	18.89	0.0416	64.77	0.52	0.80	0.87
1538-1541	2-101	S1107/32	3.12	5.47	1.90	2.15	15.90	0.0389	67.51	0.40	1.06	0.56
1550-1552	2-102	/33	3.40	5.73	2.34	2.45	6.55	0.0446	74.93	0.50	1.19	0.95
1572-1574	2-103	/34	6.76	9.44	2.88	3.80	3.39	0.0689	64.77	0.30	2.22	0.50
1614-1617	2-104	/35	1.53	3.48	1.19	1.22	3.59	0.0399	84.46	0.40	0.80	0.84
1628-1632	2-105	S1114/1	4.06	5.20	3.20		2.62	0.0513	80.65	0.32	1.46	0.70
1632-1634	2-106	/2	7.28	8.41	4.00		3.16	0.0716	69.22	0.36	2.19	0.78
1634-1636	2-107	/3	5.11	6.44	3.00		2.70	0.0569	77.47	0.40	1.63	0.68
1659-1661	2-108	/4	0.15	0.51	0.08		3.11	0.0176	92.71	0.36	0.12	0.68
1666-1670	2-109	/5	3.86	4.55	3.20		1.45	0.0331	81.28	0.24	1.09	0.52
1706-1710	2-110	/6	2.10	2.82	2.00		1.56	0.0333	88.90	0.24	0.67	0.44
1710-1715	2-111	/7	2.53	3.18	2.40		1.96	0.0353	88.90	0.36	0.72	0.54
2509-2513	2-112	/8	0.70	2.08	2.00		12.09	0.0156	82.92	0.48	0.22	0.87
2513-2516	2-113	/9	1.20	2.95	2.00		20.17	0.0123	71.25	0.84	0.32	1.29
2516-2520	2-114	/10	1.32	4.84	3.20		39.00	0.0173	47.63	0.80	0.42	1.28
2520-2523	2-115	/11	1.73	3.74	2.00		28.48	0.0137	61.59	1.02	0.38	1.46
2523-2526	2-116	/12	1.14	3.23	1.20		25.05	0.0120	66.68	0.84	0.30	1.17
2526-2529	2-117	/13	1.11	3.24	1.60		21.91	0.0156	68.58	0.68	0.38	1.07
2529-2532	2-118	/14	1.50	3.52	3.20		25.64	0.0156	62.23	0.96	0.32	1.41
2532-2536	2-119	/15	1.01	2.66	0.80		20.03	0.0110	73.03	0.86	0.26	1.27
2536-2539	2-120	/16	0.87	2.33	1.40		18.18	0.0120	74.92	0.90	0.30	1.34
2556-2559	2-121	/17	1.15	3.25	3.20		21.19	0.0147	69.22	1.08	0.24	1.52
2591-2594	2-122	/18	1.22	3.12	2.40		25.79	0.0143	64.77	0.80	0.24	1.21
2594-2598	2-123	S1115/1	1.68	3.41	2.88		24.72	0.0169	64.77	0.80	0.46	1.05
2598-2600	2-124	/2	1.27	2.67	1.60		24.41	0.0123	66.68	0.90	0.21	1.20
2600-2603	2-125	/3	1.55	3.10	1.92		27.66	0.0136	60.96	0.78	0.25	1.07
2603-2605	2-126	/4	1.53	2.85	2.40		22.10	0.0147	69.85	0.84	0.24	1.42

PUGWASH DEPOSIT, CUMBERLAND AREA

Table 4-8. Chemical analyses, potash sections in Pugwash Mine*

Sample Locality (see Fig. 4-32)	Sample Number	Sampled Interval (Feet)	% K
B_2	0	Composite, 5 feet	6.60
B_2	1	1	6.50
B_2	2	1	4.80
B_2	3	1	5.55
B_2	4	1	1.85
B_2	5	1	0.90
B_3A	0	Composite, 2 feet	10.93
B_3A	1	1	3.83
B_3A	2	1	6.38
B_4	0	Composite, 4 feet	5.15
B_4	2	1	10.00
B_4	3	1	9.60
B_4	4	1	10.48
B_4	5	1	7.80
B_5	0	Composite, 3 feet	9.95
B_5	1	1	11.20
B_5	2	1	14.23
B_5	3	1	6.48
B_6	0		7.94

*Data after J. E. Meilke, Nova Scotia Research Foundation (1962).

PUGWASH DEPOSIT-CUMBERLAND AREA

Table 4-9. Chemical analyses, potash in CRSC-58 and CRSC- 59, Pugwash, Nova Scotia.

Drillhole CRSC-58*

Interval (ft.)	Equivalent	
	% K_2O	% K
203 - 210	0.26	0.22
210 - 215	0.28	0.23
215 - 220	0.26	0.22
220 - 225	0.25	0.21
230 - 235	0.26	0.22
240 - 245	0.47	0.39
245 - 250	0.31	0.26
250 - 255	0.23	0.19
255 - 260	0.28	0.23
260 - 265	0.25	0.21
265 - 270	0.22	0.18
270 - 275	0.22	0.18
280 - 285	0.28	0.23
285 - 290	0.20	0.17
290 - 295	0.24	0.20
295 - 300	0.23	0.19
300 - 305	0.24	0.20
305 - 310	0.24	0.20
310 - 315	0.28	0.23
315 - 320	0.25	0.21
320 - 325	0.29	0.24
325 - 330	0.25	0.21
330 - 335	0.20	0.17
340 - 345	0.22	0.18
350 - 355	0.22	0.18
355 - 360	0.24	0.20
360 - 365	0.31	0.26
370 - 375	0.17	0.14
375 - 380	0.19	0.16
380 - 385	0.20	0.17
395 - 400	0.24	0.20
400 - 405	0.23	0.19
410 - 415	0.20	0.17
415 - 420	0.19	0.16
420 - 425	0.19	0.16
430 - 435	0.24	0.20
440 - 445	0.19	0.16
450 - 455	0.23	0.19
460 - 465	0.14	0.12
465 - 470	0.18	0.15
470 - 475	0.29	0.24
475 - 480	0.34	0.28
480 - 485	0.31	0.26
485 - 490	0.36	0.30
490 - 495	0.19	0.16
495 - 500	0.24	0.20
500 - 505	0.23	0.19
505 - 510	0.18	0.15
510 - 515	0.17	0.14
515 - 520	0.25	0.21
520 - 525	0.37	0.31
525 - 530	0.23	0.19
530 - 535	0.36	0.30
535 - 540	0.43	0.36
540 - 545	0.28	0.23
545 - 550	0.16	0.13
550 - 555	0.31	0.26
555 - 560	-	-
560 - 565	0.40	0.33
565 - 570	0.41	0.34
570 - 575	0.31	0.26
575 - 580	0.37	0.31
580 - 585	0.38	0.32
585 - 590	0.44	0.37
590 - 595	0.35	0.29
595 - 600	0.36	0.30
600 - 605	0.30	0.25
605 - 610	0.35	0.29
610 - 615	0.56	0.47
615 - 620	0.49	0.41
620 - 625	0.68	0.57
625 - 630	0.34	0.29
630 - 635	0.22	0.18
635 - 640	0.24	0.20
640 - 645	0.26	0.22
645 - 650	0.77	0.64
650 - 655	0.40	0.33
655 - 660	-	-
660 - 665	0.61	0.51
665 - 670	0.71	0.59
670 - 675	0.70	0.58
675 - 680	0.76	0.63
680 - 685	0.49	0.41
685 - 690	0.49	0.41
690 - 695	0.28	0.23
695 - 700	0.35	0.29
700 - 705	0.18	0.15
705 - 710	0.35	0.29
710 - 715	0.47	0.39
715 - 720	0.60	0.50
720 - 725	0.62	0.52
725 - 730	0.91	0.76
730 - 735	0.50	0.42
735 - 740	0.74	0.62
740 - 745	0.64	0.53
745 - 750	0.68	0.57
750 - 755	0.64	0.53
755 - 760	0.67	0.56
760 - 765	0.72	0.60
765 - 770	0.66	0.55
770 - 775	0.54	0.45
775 - 780	0.71	0.59
780 - 785	1.25	1.59
785 - 790	1.19	0.99
790 - 795	1.35	1.12
795 - 800	0.60	0.50
800 - 805	0.60	0.50
805 - 810	0.48	0.40
810 - 815	0.60	0.50
815 - 820	0.79	0.66
820 - 825	0.71	0.59
825 - 830	0.42	0.35
830 - 835	0.64	0.53
835 - 840	0.74	0.62
840 - 845	0.50	0.42
845 - 850	1.12	0.93
850 - 855	1.13	0.94
855 - 860	3.42	2.85
860 - 865	2.16	1.80
865 - 870	1.00	0.83
870 - 875	0.90	0.75
875 - 880	0.70	0.58
880 - 885	0.40	0.33
885 - 890	1.32	1.10
890 - 895	3.06	2.55
895 - 900	1.03	0.86
900 - 905	0.66	0.55
905 - 910	1.07	0.89
910 - 915	1.05	0.87
915 - 920	0.83	0.69
920 - 925	0.89	0.74
925 - 930	0.89	0.74
930 - 935	0.49	0.41
935 - 940	0.64	0.53
940 - 945	1.14	0.95
950 - 955	0.83	0.69
955 - 960	0.94	0.78
960 - 965	0.58	0.48
965 - 970	0.64	0.53
970 - 975	0.52	0.43
975 - 980	0.58	0.48
980 - 985	0.40	0.33
985 - 990	0.79	0.66
990 - 995	1.14	0.95
1995 - 1000	1.32	1.10
1000 - 1005	0.48	0.40
1005 - 1010	0.43	0.36
1010 - 1015	0.41	0.34
1015 - 1020	0.46	0.38
1020 - 1025	0.39	0.32
1025 - 1030	0.97	0.81
1030 - 1035	0.92	0.77
1035 - 1040	1.08	0.90
1040 - 1045	0.70	0.58
1045 - 1050	0.66	0.55
1050 - 1052	1.50	1.25

Drillhole CRSC-59**

Interval (ft.)	Equivalent	
	% K_2O	% K
132 - 135	0.022	0.018
135 - 140	0.014	0.012
140 - 145	0.010	0.008
145 - 148	0.020	0.016
172 - 175	0.025	0.021
175 - 180	0.041	0.034
180 - 185	0.007	0.006
185 - 190	0.012	0.010
190 - 192	0.012	0.010
280 - 285	0.012	0.010
285 - 288	0.010	0.008
290 - 295	0.022	0.018
296 - 301	0.046	0.038
305 - 310	0.014	0.012
310 - 315	0.024	0.020
320 - 325	0.010	0.008
535 - 540	0.010	0.008
540 - 545	0.026	0.022
545 - 550	0.010	0.008
1180 - 1185	0.11	0.090
1185 - 1190	0.09	0.078
1190 - 1195	0.17	0.141
1195 - 1200	0.23	0.188
1200 - 1205	0.83	0.690
1205 - 1207	4.32	3.60
1210 - 1212	4.69	3.91
1230 - 1234	0.24	1.97
1240 - 1244	0.74	0.620
1330 - 1333	0.37	0.310
1349 - 1351	0.44	0.363
1390 - 1395	0.28	0.233
1395 - 1400	0.38	0.318
1405 - 1410	0.66	0.450
1410 - 1415	1.03	0.863
1415 - 1420	1.05	0.875
1420 - 1425	0.93	0.775
1425 - 1430	0.21	0.178
1430 - 1435	0.78	0.652
1435 - 1440	0.62	0.520

*Analyst W. M. Langille, Nova Scotia Research Foundation (1962)

**Nova Scotia Research Foundation (1962)

ROSLIN OCCURRENCE-CUMBERLAND AREA

Roslin No. 1 core samples, analyses in per cent*

Depth (ft.)	Sample Lab No.	K (total)	Moisture	K (sol.)	Br	Insoluble	Na	Cl**	Ca	Mg	SO_4
375	5839/1		5.51	0.025		87.60	1.88	2.02	0.82	0.02	2.06
378	2		4.71	0.050		45.87	16.00	26.16	1.86	0.02	4.47
381	3		3.54	0.023		47.56	17.50	29.21	0.88	0.01	2.15
385	4		3.17	0.040		39.76	19.63	34.50	1.26	nil	3.03
387	5		5.25	0.060		60.05	11.25	19.66	1.80	0.015	4.33
390	6		3.57	0.040		66.62	11.13	17.46	0.40	0.03	0.95
395	7		6.09	0.050		52.19	12.50	20.37	2.00	0.03	4.77
398	8		3.79	0.040		22.45	24.63	41.75	1.70	0.02	4.10
404	5856/1		4.22	0.072		51.05	17.00	27.90	0.82	0.03	1.90
406	2		4.05	0.050	0.0034	32.73	22.25	36.92	1.42	0.03	3.27
413	3		4.25	0.044		52.87	16.00	28.04	0.93	0.03	2.09
422	4		3.37	0.050	0.0032	53.84	16.00	25.63	1.10	0.03	2.38
436	5		8.50	0.064		56.97	12.75	20.80	1.26	0.06	2.44
444	6		4.48	0.060	0.0034	49.96	16.50	27.47	1.36	0.05	2.81
457	7		1.79	0.020		23.65	27.00	44.20	1.65	0.02	3.74
472	8		2.77	0.050	0.0034	47.10	19.50	31.95	0.43	0.03	0.87
479	9		2.24	0.032		22.85	27.50	44.80	1.22	0.06	2.77
490	10		3.12	0.040	0.0032	53.85	15.50	26.84	0.34	0.05	0.61
503	11		4.03	0.038		41.15	20.50	33.01	1.26	0.04	2.88
513	12		3.05	0.035	0.0041	34.89	24.00	39.76	0.29	0.04	0.66
522	13	1.00	3.88	0.055		35.11	22.50	38.12	1.20	0.03	2.51
526	14	1.30	4.93	0.040	0.0033	50.29	17.00	30.31	0.77	0.04	1.67
535	15	1.30	5.57	0.040		51.02	16.25	27.19	1.18	0.04	2.54
539	16	0.90	3.72	0.080	0.0047	29.05	26.00	43.09	0.80	0.04	1.88
543	17	0.90	4.28	0.025		35.94	19.25	37.27	0.82	0.04	1.87
547	18	0.70	3.81	0.038	0.0047	37.51	22.50	36.95	0.78	0.03	1.68
553	19	1.35	4.25	0.080		49.08	18.25	28.61	1.15	0.04	2.44
557	20	0.60	2.94	0.055	0.0041	30.41	25.00	41.18	1.18	0.04	2.81
562	21	0.75	3.90	0.065		44.01	20.75	29.96	0.91	0.05	2.00
573	22		3.32	0.050	0.0038	47.21	19.25	30.53	0.72	0.04	1.54
577	23		3.60	0.050		52.85	16.50	29.82	0.88	0.03	1.89
590	24		3.51	0.050	0.0032	42.29	21.50	34.65	0.64	0.06	1.36
596	25		2.76	0.038		43.28	21.00	34.29	0.66	0.03	1.43
609	5890/1	3.04		0.20	0.0047	36.86	21.75	33.50	0.81	0.063	2.00
623	2	3.74		0.016		60.20	13.25	20.40	0.58	0.087	1.20
645	3	3.68		0.016		49.46	16.75	25.80	0.57	0.034	1.20
663	4	2.74		0.012		34.04	21.50	33.11	0.77	0.029	1.60
689	5	1.61		0.020	0.0047	26.58	24.25	37.34	0.75	0.019	1.60
709	6	2.66		0.032		30.01	23.50	36.19	1.12	0.058	2.49
727	7	3.36		0.076		52.49	14.75	22.71	0.96	0.058	2.20
754	8	5.33		0.072		59.68	11.00	16.94	1.22	0.087	2.40
775	9	1.91		0.012	0.0053	41.13	20.00	30.80	0.58	0.009	1.00
797	10	3.05		0.012		34.02	22.00	33.88	1.02	0.075	2.20
815	11	3.98		0.024		66.79	10.75	16.55	0.35	0.048	0.60
834	12	2.29		0.028		26.37	24.50	37.73	0.75	0.024	1.60
844	13	2.23		0.036	0.0043	40.20	20.75	31.95	0.42	0.034	0.60
854	14	1.02		0.032		19.66	28.50	43.89	0.56	0.048	1.20
868	15	3.00		0.036		59.90	13.50	20.79	0.35	0.039	0.40
889	16	2.70		0.064		53.53	15.50	23.87	0.37	0.029	0.60
905	17	2.51		0.060	0.0050	32.02	23.00	35.42	0.67	0.034	1.40
925	18	2.58		0.032		40.52	20.00	30.80	0.61	0.044	1.20
936	19	2.54		0.072		54.29	15.25	23.45	0.43	0.068	0.60
952	20	1.84		0.064		44.11	19.25	29.64	0.58	0.048	1.00
965	21	3.34		0.072	0.0063	42.67	17.75	27.33	1.09	0.034	2.20
975	22	2.38		0.012		37.66	21.25	32.72	0.72	0.029	1.40
990	23	2.81		0.036		34.76	21.00	32.34	0.90	0.078	1.80
1005	24	2.23		0.072		40.80	21.00	32.34	0.26	0.116	0.20

*Nova Scotia Department of Mines (1966a)

**Analyst reports the chloride determination of high NaCl concentrations appears to run about two per cent higher than that calculated from the sodium determination; this would make the total mineral content closer to 100 per cent

MCINTYRE LAKE DEPOSIT-CANSO-BRAS D'OR AREA

CANSO STRAT NO. 2 SALT ANALYSES METHODS

Sample Preparation

Received samples were crushed to -10 mesh through a jaw crusher and cone crusher. A sample for analysis was split out with a Jones splitter, dried at 110°C in an oven and crushed to -200 mesh in a shatterbox.

Analytical Method

Ten grams of sample were weighed into a 100 ml beaker and 25 ml of distilled water added. The beaker was placed in a magnetic stirrer, stirred for 15 minutes and filtered through a weighed medium porosity filter crucible. The brine solution was saved in a plastic bottle for further analysis, while the residue on the filter crucible was washed free of chloride with distilled water, dried at 110°C for 1 hour and reweighed to give the per cent water insoluble.

The chloride content of the brine solution was determined on an aliquot portion using the method of Volhord, p. 271, 5th edition, Scotts Standard Methods of Chemical Analysis.

SO_4 was determined on a 10 ml aliquot by precipitation as barium sulphate.

Ca, Mg and K were determined on a suitable aliquot by atomic absorbtion spectrophotometry using standards matching the NaCl content of the sample and maintaining a 1% lanthanum chloride content in both the samples and standards to suppress interferences from SO_2.

The specific gravity of the brine solution was determined on a 10 ml portion using a pycnometer.

The NaCl content was calculated from the chloride content as follows: total chloride - chloride from KCl = chloride from NaCl, chloride from NaCl x 1.65 = NaCl content. NaCl, K, Ca, Mg and SO_4 were reported % w/w from the % w/v using the specific gravity of the brine solution.

Notes: (after Hale, 1974)

The Percentage Water Insoluble column is the total insoluble of the original sample at room temperature (20°C or 68°F).

The Specific Gravity column is the specific gravity of the brine solution at room temperature (20°C or 68°F).

For saturated salt water the specific gravity is 1.20254 at 50°F (1.20104 at 20°C calculated). Any increase in specific gravity above 1.20104 can be attributed to other soluble materials (such as potash salts).

The Sodium Chloride Percentage is the percentage of NaCl in a saturated aqueous solution. At 20°C room temperature 26 per cent will be the maximum percentage obtainable, i.e. grams of salt (NaCl) in 100 gm of brine solution.

Whenever the insolubles are about 10%, the sodium chloride percentage of 26% will never be reached.

The Parts per Million (1/1 000 000) column represents the amount of each element (Ca, SO_4, or Mg) dissolved out of the original sample, which is in solution as a brine solution. All materials are related to the brine solution as grams of material to 100 gm of brine solution (600 ppm = 0.06%).

The analytical procedure starts in volumes (grams of sample in 100 cc or ml of solution), specific gravity is taken and a conversion is made to grams of soluble material in 100 cc of brine solution. This is converted to grams of soluble material in 100 grams of brine solution (by using the specific gravity). The percentage NaCl is calculated by reducing the equivalent Cl for the amount of K. In the case of carnallite ($KMgCl_3\ 6H_2O$ or $KCl.MgCl_2.6H_2O$ - K = 14.1%), there will be a slight excess of Cl attributable to the Na.

This analytical procedure and presentation of results is the same as that requested and provided for Dow Chemical of Canada Limited for their Port Richmond core samples.

MCINTYRE LAKE DEPOSIT - CANSO BRAS D'OR AREA

Chemical analyses Canso Strat No. 2, McIntyre Lake deposit

SAMPLE DEPTH FEET	WATER INSOL %	SPECIFIC GRAVITY	SODIUM CHLORIDE %	PARTS PER MILLION			
				CA	SO4	K	MG
837- 840	5.1	1.200	26.0	600	1766	72	3
840- 850	4.5	1.203	25.9	600	1777	65	2
850- 860	4.9	1.203	25.9	541	1277	33	2
860- 870	1.7	1.204	26.0	1029	2397	23	3
870- 880	1.0	1.204	26.0	1262	2997	3	2
880- 890	1.4	1.204	25.9	1196	2870	38	4
890- 900	3.5	1.204	25.9	7	1911	49	6
900- 910	8.8	1.202	26.0	915	2206	43	4
910- 920	7.3	1.203	25.9	833	2111	33	1
920- 930	3.2	1.203	26.0	420	937	50	1
930- 940	1.9	1.203	26.0	500	1525	147	2
940- 950	19.1	1.180	23.5	1183	2865	325	550
950- 960	29.0	1.165	21.0	1390	2945	729	521
960- 970	27.2	1.175	21.2	1868	3549	882	349
970- 980	19.3	1.176	22.5	1513	2735	680	18
980- 990	19.4	1.181	23.4	1343	2687	609	375
990-1000	39.0	1.139	18.0	1910	3670	830	553
1000-1010	46.6	1.121	15.5	2109	3457	400	479
1010-1020	1.7	1.204	26.0	482	1374	392	5
1020-1030	1.1	1.201	25.9	332	1374	116	4
1030-1040	1.8	1.204	26.0	802	1956	56	4
1040-1050	11.4	1.201	26.0	448	1178	30	4
1050-1060	1.0	1.203	26.0	914	2285	36	2
1060-1070	.5	1.204	26.0	1145	1591	525	6
1070-1080	.4	1.203	26.0	266	586	665	7
1080-1090	1.1	1.204	26.0	797	1914	119	4
1090-1100	15.9	1.189	24.0	1261	2851	303	187
1100-1110	15.0	1.192	24.3	872	1714	406	151
1110-1120	26.8	1.169	24.2	1026	1470	256	211
1120-1130	40.1	1.139	18.3	1421	1824	316	333
1130-1140	50.3	1.114	15.3	915	258	262	344
1140-1150	27.3	1.168	21.9	1061	1570	157	155
1150-1160	8.4	1.204	25.9	1096	2207	176	79
1160-1170	36.8	1.148	18.9	1655	4101	45	12
1170-1180	47.8	1.125	15.9	2080	4852	42	7
1180-1190	13.0	1.190	24.3	1109	2576	32	3
1190-1200	53.6	1.124	14.3	2064	4928	46	10
1200-1210	35.8	1.153	19.7	1630	4079	41	3
1210-1220	17.7	1.188	24.0	1616	2854	255	64
1220-1230	19.7	1.184	23.3	1414	3283	40	10
1230-1240	67.8	1.076	9.5	1719	4491	37	14
1240-1250	52.4	1.136	14.2	2482	4332	91	309
1250-1260	50.2	1.118	15.0	2540	3004	175	85
1260-1270	42.1	1.138	18.2	422	233	189	35
1270-1280	82.9	1.035	4.0	1816	4419	34	19
1280-1290	61.4	1.095	12.0	2283	5191	43	18
1290-1300	57.2	1.096	12.1	2883	3888	182	91
1300-1310	44.5	1.130	16.8	2213	2870	219	12
1310-1320	73.7	1.050	6.8	2876	1102	300	224
1320-1330	71.1	1.071	9.8	466	82	75	41
1330-1340	40.1	1.143	19.3	315	62	221	28
1340-1350	95.3	1.000	1.0	1000	1695	280	33
1350-1360	37.2	1.147	18.7	1569	5049	69	3
1360-1370	14.3	1.195	24.5	702	2140	133	3
1370-1380	16.5	1.190	24.0	1176	3077	12	11

MCINTYRE LAKE DEPOSIT - CANSO BRAS D'OR AREA

Chemical analyses Canso Strat No. 2, McIntyre Lake deposit

SAMPLE DEPTH FEET	WATER INSOL %	SPECIFIC GRAVITY	SODIUM CHLORIDE %	PARTS PER MILLION			
				CA	SO4	K	MG
1380-1390	47.3	1.126	16.3	1848	5125	40	16
1390-1400	27.3	1.166	21.3	1372	4114	61	17
1400-1410	6.5	1.204	25.9	913	2942	43	59
1410-1420	2.2	1.203	25.9	1014	3431	66	3
1420-1430	17.2	1.188	23.5	1430	4147	33	4
1430-1440	24.4	1.190	23.9	1210	2383	47	5
1440-1450	24.5	1.174	22.6	1100	2135	61	17
1450-1460	21.6	1.178	22.6	1690	3200	67	17
1460-1470	25.5	1.175	22.4	1872	2818	102	17
1470-1780	15.7	1.192	24.4	1442	3129	654	6
1480-1490	19.7	1.183	23.3	1487	3091	53	6
1490-1500	24.0	1.173	22.0	1656	3663	53	6
1500-1510	39.4	1.162	20.7	1738	3715	54	7
1510-1520	17.3	1.187	23.9	1179	2255	53	6
1520-1530	24.2	1.174	22.2	1500	2572	70	9
1530-1540	17.0	1.187	23.9	1600	3093	71	10
1540-1550	44.5	1.129	16.4	2214	4331	75	10
1550-1560	41.7	1.136	17.1	2112	4123	73	9
1560-1570	22.5	1.175	22.6	1550	2966	140	23
1570-1580	51.9	1.112	14.3	2430	3763	107	18
1580-1590	9.2	1.193	25.5	1260	2746	67	10
1590-1600	8.2	1.203	25.6	1400	3073	46	6
1600-1610	11.6	1.197	25.0	1269	3252	46	6
1610-1620	6.8	1.201	25.9	1165	2867	45	6
1620-1630	13.1	1.193	24.6	1320	3274	47	5
1630-1640	13.1	1.195	24.7	1523	3582	46	5
1640-1650	28.1	1.164	20.8	1800	3600	72	22
1650-1660	30.4	1.160	20.5	1750	3229	69	24
1660-1670	22.0	1.177	22.3	1540	3590	47	10
1670-1680	18.5	1.184	23.4	1520	3240	57	13
1680-1690	54.1	1.108	14.0	2436	4123	111	36
1690-1700	14.3	1.192	24.4	1442	3376	46	10
1700-1710	22.7	1.178	22.9	1120	2136	57	16
1710-1720	11.7	1.200	25.1	1280	3377	43	5
1720-1730	13.3	1.192	25.0	1325	3193	41	50
1730-1740	20.1	1.182	23.3	1522	3077	50	15
1740-1750	22.6	1.176	22.5	1666	3577	61	15
1750-1760	8.1	1.205	26.0	1261	2917	46	6
1760-1770	5.4	1.205	26.0	1260	2897	46	6
1770-1780	29.7	1.161	20.6	1620	4033	24	8
1780-1790	96.1	1.001	1.0	1150	2745	24	12
1790-1800	75.2	1.062	7.7	2070	5750	37	7
1800-1810	80.6	1.037	4.4	1697	4243	42	27
1810-1820	62.9	1.082	10.9	440	467	50	18
1820-1830	81.0	1.032	4.3	1647	2037	124	68
1830-1840	93.6	1.010	1.3	1366	2310	63	27
1840-1850	60.4	1.094	12.0	2260	4035	91	58
1850-1860	68.5	1.071	8.9	2370	4518	112	56
1860-1870	68.4	1.071	8.8	2330	4814	111	52
1870-1880	67.5	1.072	9.0	2330	4337	111	59
1880-1890	75.5	1.051	6.4	2640	3891	133	83
1890-1900	80.3	1.039	4.8	2290	3318	128	88
1900-1910	67.4	1.070	8.9	2355	4307	112	67
1910-1920	55.4	1.093	11.8	2470	3807	132	102
1920-1930	54.2	1.107	13.7	2059	4160	108	83

McINTYRE LAKE DEPOSIT - CANSO BRAS D'OR AREA

Chemical analyses Canso Strat No. 2, McIntyre Lake deposit

SAMPLE DEPTH FEET	WATER INSOL %	SPECIFIC GRAVITY	SODIUM CHLORIDE %	PARTS PER MILLION			
				CA	SO4	K	MG
1930-1940	59.9	1.089	11.0	2020	4355	91	77
1940-1950	74.5	1.062	7.8	2110	4340	94	86
1950-1960	63.1	1.090	11.4	1926	5096	58	40
1960-1970	42.8	1.135	17.2	1750	4709	57	21
1970-1980	6.5	1.204	25.9	1079	2901	43	59
1980-1990	21.9	1.178	22.6	1477	3315	44	61
1990-2000	14.1	1.193	24.6	1257	2979	43	53
2000-2010	50.9	1.093	13.4	2086	3636	80	40
2010-2020	44.2	1.134	17.1	1975	4044	53	24
2020-2030	46.0	1.131	16.8	1980	4046	46	24
2030-2040	33.5	1.156	19.9	1591	3508	51	17
2040-2050	17.4	1.184	23.4	1266	3208	38	10
2050-2060	38.9	1.144	18.1	1850	3637	91	30
2060-2070	26.0	1.173	22.2	1483	3622	38	6
2070-2080	34.6	1.155	19.7	1731	3656	44	6
2080-2090	31.9	1.161	20.5	1533	3306	51	10
2090-2100	11.5	1.200	25.4	1100	2899	36	6
2100-2110	51.2	1.117	15.1	1969	4985	53	10
2110-2120	68.9	1.078	9.1	2050	5153	37	7
2120-2130	94.3	1.013	1.4	1283	3638	39	7
2130-2140	51.2	1.119	14.9	1876	5289	39	7
2140-2150	1.4	1.204	26.0	980	2760	36	6
2150-2160	4.7	1.204	25.9	1063	2850	36	6
2160-2170	1.1	1.204	25.9	665	1264	43	5
2170-2180	29.2	1.164	20.9	1838	3680	68	20
2180-2190	14.4	1.196	24.7	1170	2572	63	10
2190-2200	32.7	1.157	19.9	1815	3455	96	20
2200-2210	26.0	1.170	21.3	1692	3644	68	15
2210-2220	21.3	1.183	23.1	1606	3165	64	15
2220-2230	28.1	1.167	21.0	1714	3753	103	15
2230-2240	7.7	1.204	26.0	1226	3230	40	15
2240-2250	1.2	1.204	26.0	913	1756	51	8
2250-2260	.4	1.203	26.0	432	1089	51	4
2260-2270	1.8	1.205	26.0	836	2301	43	9
2270-2280	1.5	1.204	26.0	830	1921	29	8
2280-2290	17.6	1.190	23.7	1411	3361	20	18
2290-2300	34.4	1.155	20.1	1662	3259	69	41
2300-2310	55.0	1.111	14.0	2322	4935	72	36
2310-2320	87.6	1.033	3.5	2032	4885	24	6
2320-2330	47.7	1.128	16.1	2021	4908	46	17
2330-2340	54.8	1.109	13.8	2596	4896	86	55
2340-2350	32.4	1.158	19.8	1813	4279	44	20
2350-2360	83.1	1.045	5.3	2375	5579	23	15
2360 2370	NOT SAMPLED ANHYDRITE (NIL SALT)						
2370 2380	NOT SAMPLED ANHYDRITE (NIL SALT)						
2380 2390	NOT SAMPLED ANHYDRITE (NIL SALT)						
2390 2400	NOT SAMPLED ANHYDRITE (NIL SALT)						
2400 2410	NOT SAMPLED ANHYDRITE (NIL SALT)						
2410 2420	NOT SAMPLED ANHYDRITE (NIL SALT)						
2420 2430	NOT SAMPLED ANHYDRITE AND LIMESTONE (NIL SALT)						
2430 2440	NOT SAMPLED LIMESTONE (NIL SALT)						
2440 2450	NOT SAMPLED LIMESTONE (NIL SALT)						
2450 2460	NOT SAMPLED LIMESTONE (NIL SALT)						
2460 2470	NOT SAMPLED ANHYDRITE AND LIMESTONE (NIL SALT)						
2470 2480	NOT SAMPLED ANHYDRITE AND LIMESTONE (NIL SALT)						

MCINTYRE LAKE DEPOSIT - CANSO BRAS D'OR AREA

Chemical analyses Canso Strat No. 2, McIntyre Lake deposit

SAMPLE DEPTH FEET	WATER INSOL %	SPECIFIC GRAVITY	SODIUM CHLORIDE %	PARTS PER MILLION			
				CA	SO4	K	MG
2480 2490	NOT SAMPLED ANHYDRITE (NIL SALT)						
2490 2500	NOT SAMPLED ANHYDRITE (NIL SALT)						
2500-2510	13.0	1.195	24.8	1272	2896	60	56
2510-2520	14.5	1.195	25.0	1405	3364	26	13
2520-2530	14.7	1.191	24.4	1444	3371	47	6
2530-2540	50.8	1.114	14.4	2603	4740	79	43
2540-2550	30.1	1.162	20.5	1480	2750	68	31
2550-2560	26.9	1.169	21.2	1622	3289	51	27
2560-2570	29.6	1.162	20.5	1652	3397	51	17
2570-2580	23.9	1.174	21.8	1635	3588	51	13
2580-2590	31.2	1.160	20.5	1275	2245	51	17
2590-2600	6.9	1.205	25.9	1195	2690	48	6
2600-2610	39.0	1.144	18.6	1503	2504	52	21
2610-2620	41.1	1.138	17.9	1318	2152	66	21
2620-2630	25.7	1.171	22.0	1280	2364	17	17
2630-2640	22.3	1.179	22.3	610	419	54	13
2640-2650	33.7	1.155	19.9	1714	3110	55	20
2650-2660	21.3	1.181	22.9	1456	3184	55	13
2660-2670	7.0	1.204	25.9	1212	2673	33	6
2670-2680	17.3	1.188	24.0	1435	3055	47	10
2680-2690	12.8	1.198	24.9	1400	3249	46	6
2690-2700	11.8	1.200	25.5	1250	2743	46	10
2700-2710	38.8	1.162	20.6	1483	4080	77	26
2710-2720	29.7	1.143	29.7	2099	4215	80	24
2720-2730	24.8	1.173	22.0	1688	3466	58	17
2730-2740	45.6	1.129	16.5	2409	4743	134	24
2740-2750	17.7	1.187	23.6	1331	3032	77	16
2750-2760	27.5	1.166	21.1	1698	3630	61	20
2760-2770	10.0	1.202	25.9	1247	3026	76	9
2770-2780	5.6	1.205	26.0	1212	2770	112	9
2780-2790	2.7	1.205	26.0	1095	2671	26	6
2790-2800	3.6	1.205	26.0	995	2431	26	5
2800-2810	2.5	1.205	26.0	995	2490	36	6
2810-2820	1.9	1.203	26.0	831	1877	56	9
2820-2830	7.7	1.202	25.7	1247	2910	43	8
2830-2840	9.4	1.201	25.6	1265	3062	46	10
2840-2850	8.8	1.202	25.7	1289	2976	33	10
2850-2860	6.4	1.204	25.8	1295	3000	33	6
2860-2870	5.3	1.204	26.0	1086	2614	33	8
2870-2880	28.8	1.162	20.8	1755	3829	58	20
2880-2890	26.6	1.168	21.2	1455	2357	68	20
2890-2900	46.5	1.126	15.9	1119	4752	58	24
2900-3000	50.7	1.118	14.7	1036	4898	53	16
2910-2920	38.7	1.142	18.1	928	4062	56	15
2920-2930	2.8	1.203	26.0	690	1501	34	6
2930-2940	20.3	1.183	23.3	676	3274	37	6
2940-2950	43.2	1.142	18.8	2679	2633	127	56
2950-2960	13.0	1.197	24.8	1002	2341	53	9
2960-2970	33.5	1.154	19.5	1802	3573	83	24
2970-2980	30.0	1.161	20.5	1739	4023	37	10
2980-2990	14.9	1.193	24.5	1257	2888	37	10
2990-3000	24.9	1.174	22.2	1384	1788	47	8
3000-3007	39.7	1.140	17.7	2000	4155	73	24

PORT RICHMOND DEPOSIT - CANSO-BRAS D'OR AREA

Table 7-5. Analyses of composite salt samples, drillhole DCPR-1, Port Richmond deposit (Rowe, 1967)

Interval (ft.)	Na (%)	Cl (%)	Ca (%)	SO_4 (%)	K (ppm)	Mg (ppm)	Fe*** (ppm)	Sr (ppm)	Br (ppm)	Water* Insoluble (%)	Acid** Insoluble (%)
1695.5-1782.5	31.1	47.8	2.4	6.6	70	20	-	130	35	11.0	40.9
1782.5-1792.5	32.6	47.2	0.9	2.3	260	55	-	55	35	17.2	80.5
1792.5-1810.5	20.2	31.8	2.2	5.6	250	90	15	90	35	38.6	37.9
1825-1832.5	29.5	41.9	2.1	5.4	240	43	-	90	25	21.8	53.8
1832.5-1887.5	33.8	48.5	1.6	3.8	310	15	-	80	40	9.9	62.5
1887.5-2015	34.2	52.2	1.3	2.9	250	25	-	65	50	7.6	54.1
2015-2115	28.7	42.8	1.9	4.7	60	10	-	100	35	21.3	57.4
2115-2195	31.6	49.3	1.6	3.8	80	20	-	95	45	12.0	58.0
2195-2295	33.2	50.8	1.6	4.0	70	15	-	80	75	8.9	54.9
2295-2375	33.8	50.6	1.5	3.4	70	20	-	70	45	9.1	57.8
2375-2435	31.6	48.2	1.5	1.1	60	10	-	80	35	12.6	56.7
2435-2495	31.3	46.6	1.8	4.6	60	20	-	95	40	14.2	58.4

*100% - % water insoluble = % NaCl ** In 20% HCl at 80° for 30 minutes *** - Fe less than 10 ppm

NOTE: 5 g sample in 250 ml H_2O at 80°F, analysis are of water soluble fraction; I less than 1 ppm in all samples.

Table 7-6. Analyses of composite salt samples (salt core basis) drillhole DCPR-2, Port Richmond deposit* (Rowe, 1968a)

Interval (ft.)	Na (%)	Cl (%)	Ca (%)	SO_4 (%)	K (ppm)	Mg (ppm)	Fe (ppm)	Sr (ppm)	CO_3 (ppm)	I** (ppm)	Br (ppm)	Water Insoluble (ppm)	Acid Insoluble (%)
1802-1853	35.4	54.4	0.52	1.12	0.010	12	0.007	31	153	-	34	8.32	4.41
1861-1891	32.8	50.5	0.59	1.18	0.040	47	0.007	38	129	-	44	13.9	11.1
1891-1946	30.7	47.2	0.68	1.34	0.034	56	0.008	49	216	-	37	19.3	15.2
1946-1956	13.0	21.0	0.86	1.90	0.071	200	0.026	100	135	-	32	61.8	46.3
1956-1986	33.2	50.9	0.58	1.18	0.060	97	0.016	41	128	-	39	13.3	8.11
1986-2001	32.2	50.5	0.65	1.32	0.29	190	0.032	38	130	-	55	13.2	9.72
2001-2015	27.0	43.0	0.65	1.18	1.05	400	0.020	52	181	-	89	25.9	22.2
2015-2036	27.7	44.4	0.69	1.42	0.26	300	0.057	28	130	-	52	23.8	19.4
2036-2051	24.5	37.9	0.74	1.54	0.18	240	0.012	34	166	-	37	33.7	26.5
2051-2066	30.1	42.5	1.39	2.60	0.24	260	0.057	25	129	-	47	18.5	14.2
2066-2081	29.8	46.1	0.69	1.49	0.086	170	0.085	27	153	-	37	21.0	16.7
2081-2110	32.0	50.7	0.58	1.35	0.029	86	0.057	23	128	-	22	16.4	12.7

*Analyst, R. A. Bredeweg, Analytical Laboratories

**less than 5 ppm

PORT RICHMOND DEPOSIT - CUMBERLAND AREA

Table 7-7. Analyses of composite salt samples (salt brine basis) drillhole DCPR-2, Port Richmond deposit* (Rowe, 1968a)

Interval (ft.)	Na (%)	Cl (%)	Ca (%)	SO_4 (%)	K (%)	Mg (%)	Fe (ppm)	Se (ppm)	CO_3 (ppm)	I** (ppm)	Br (ppm)	Sample (gm)	Water (gm)
1802-1853	8.70	13.3	0.13	0.27	0.0025	3	0.002	7.8	37.5	-	8.3	50.00	157.91
1861-1891	8.09	12.4	0.15	0.29	0.0099	12	0.002	9.4	31.7	-	11.0	50.02	160.10
1891-1946	7.59	11.7	0.17	0.33	0.0084	14	0.003	12.0	54.0	-	9.1	50.02	162.01
1946-1956	3.75	6.06	0.25	0.43	0.021	57	0.008	29.0	39.0	-	11.0	50.08	154.43
1956-1986	8.25	12.7	0.14	0.29	0.015	24	0.006	10.0	31.9	-	9.7	50.01	157.79
1986-2001	7.71	12.2	0.16	0.32	0.070	47	0.009	9.2	34.0	-	13.0	49.99	163.21
2001-2015	7.09	11.3	0.17	0.31	0.28	110	0.006	14.0	47.6	-	23.0	49.99	153.32
2015-2036	7.11	11.4	0.18	0.37	0.066	76	0.014	7.2	33.5	-	13.0	50.00	156.00
2036-2051	6.24	9.69	0.19	0.39	0.046	61	0.004	8.6	42.5	-	9.5	50.03	162.77
2051-2066	7.64	12.0	0.16	0.35	0.060	65	0.014	6.2	32.6	-	12.0	50.02	156.63
2066-2081	7.45	11.5	0.17	0.37	0.022	43	0.021	6.7	38.3	-	9.3	50.01	160.45
2081-2110	8.21	13.0	0.15	0.35	0.0074	22	0.014	5.8	32.8	-	5.5	50.11	153.41

*Analyst, R. A. Bredeweg, Analytical Laboratories

**less than 1 ppm.

Chemical analyses, salt core samples, DCPR-2, analyses in per cent (Rowe 1968a).

Sample Interval (ft.)	Lab No.	NSDM Sample	Br	K	NaCl	Insoluble	LOI
2029.5-2036.0 (chips)	51660/1	DCPR 2-1	0.0053	0.16	82.80	18.62	0.49
2050.3-2057.5 (chips)	2	-2	0.0040	0.44	65.79	23.95	1.69
2057.5-2064.7 (6" sample)	3	-3	0.0057	4.10	56.13	28.01	2.32
2072.0-2079.2 (6" sample)	4	-4	0.0047	0.19	68.58	21.77	1.92
2079.2-2086.4 (6" sample)	5	-5	0.0050	0.53	69.09	21.77	1.52
2086.4-2093.6 (6" sample)	6	-6	0.0050	0.16	75.44	17.54	1.26
2093.6-2100.8 (6" sample)	7	-7	0.0030	0.08	45.47	39.61	1.32
2114.8-2122.0 (6" sample)	8	-8	0.0033	0.09	73.15	18.34	1.56

*Analyses by Nova Scotia Research Foundation; K. S. Maclean, analyst (Rowe, 1968a).

PORT RICHMOND DEPOSIT-CANSO-BRAS D'OR AREA

Table 7-8. Analyses* of composite samples DCPR-3, calculated on salt core basis, Port Richmond Deposit (Ross, 1968a).

Interval (ft.)	Na (%)	Cl (%)	Ca (%)	SO_4 (%)	K (%)	Mg (ppm)	Fe** (ppm)	Sr (ppm)	CO_3 (ppm)	I*** (ppm)	Br (ppm)	Water Insoluble (%)	Acid Insoluble (%)
1742-1841	35.7	54.5	0.68	1.45	0.066	105	0.88	51	150	6.3	46	7.81	5.57
1841-1939	14.9	23.1	0.76	1.72	0.038	95	0.14	74	204	-	20	62.0	46.7
1939-2040	31.2	48.2	0.72	1.58	0.082	105	-	53	112	8.5	48	17.1	9.86
2040-2156	30.4	46.5	0.75	1.60	0.10	95	-	65	95	8.7	48	20.0	13.5
2156-2200	16.7	27.1	1.01	1.44	0.21	290	1.46	154	205	-	74	51.5	41.4
2200-2246	33.4	51.7	0.71	1.63	0.081	65	-	44	205	5.8	38	11.8	7.62
2246-2336	30.9	47.6	0.76	1.68	0.12	190	1.46	73	160	-	57	18.2	16.2
2336-2462	31.3	47.9	0.73	1.61	0.14	205	0.17	74	160	-	68	17.7	13.3
2462-2480	19.0	30.1	0.88	1.03	0.17	265	0.40	350	180	8.5	64	46.4	39.4
2480-2606	32.0	49.9	0.71	1.61	0.19	215	-	40	150	-	96	14.8	9.77
2606-2693	10.4	16.8	0.78	1.16	0.18	905	0.17	144	130	-	62	69.3	62.4
2693-2779	36.3	55.7	0.53	1.20	0.13	105	1.56	29	94	-	39	5.7	5.03
2779-2826	13.5	21.8	0.58	1.00	0.13	690	0.10	132	120	6.1	55	61.3	57.2
2826-3053	28.5	43.4	0.75	1.71	0.047	125	-	56	239	4.6	53	25.0	18.0
3053-3167	26.6	40.0	0.77	1.75	0.026	95	-	60	170	5.1	36	30.6	20.1
3167-3224	10.9	16.7	0.51	0.85	0.043	225	-	96	250	-	30	70.3	57.9
3224-3355	12.3	18.9	0.40	0.49	0.053	185	-	59	290	4.2	32	66.3	50.7
3355-3614	25.5	38.4	0.74	1.64	0.042	223	-	63	298	-	39	33.2	25.6
3667-3705	11.3	17.2	0.24	0.15	0.063	313	-	98	242	4.7	23	70.8	54.9
3846-4104	24.9	37.4	0.66	1.55	0.035	145	-	72	260	4.2	27	35.6	25.9
4104-4205	11.0	16.7	0.26	0.34	0.049	225	-	71	270	6.3	22	71.1	51.3
4205-4324	26.5	40.6	0.73	1.67	0.026	104	-	72	256	4.2	24	30.1	20.7
4324-4356	13.5	20.7	0.56	1.22	0.031	115	0.12	74	160	4.2	18	63.8	52.9
4356-4519	29.4	44.6	0.72	1.67	0.019	80	-	72	220	5.5	23	23.2	15.5
4519-4562	11.4	19.0	0.12	0.15	0.028	105	0.10	33	249	4.2	19	68.5	52.5
4562-4642	34.1	50.3	0.68	1.68	0.044	130	-	40	170	4.6	36	13.9	9.8
4642-4726	33.0	49.8	0.65	1.63	0.083	79	-	51	158	5.4	34	14.2	8.64
4726-4813	29.7	44.7	0.72	1.72	0.18	165	-	49	195	5.9	42	23.0	16.60
4813-4929	28.8	43.6	0.72	1.76	0.060	125	-	50	195	4.6	43	24.8	16.7

*Analyst, Penn Schloemann, Analytical Laboratories

**Fe less than 0.05 ppm

***I less than 4 ppm

PORT RICHMOND DEPOSIT-CANSO-BRAS D'OR AREA

Table 7-9. Analyses* of composite samples, calculated on brine basis, from drillhole DCPR-3, Port Richmond deposit (Ross, 1968b).

Interval (ft.)	Na (%)	Cl (%)	Ca (%)	SO_4 (%)	K (%)	Mg (ppm)	Fe** (ppm)	Sr (ppm)	CO_3 (ppm)	I*** (ppm)	Br (ppm)	Sample (g)	Water (g)
1742-1841	8.86	13.5	0.17	0.36	0.016	26	0.22	13	37	1.7	11	50.02	155.37
1841-1939	4.06	6.56	0.22	0.49	0.011	27	0.040	21	38	-	5.7	50.11	157.22
1939-2040	7.92	12.2	0.18	0.40	0.021	27	-	13	30	2.1	13	50.00	155.41
2040-2156	7.76	11.9	0.19	0.41	0.026	24	-	17	24	2.2	13	50.02	155.93
2156-2200	4.52	7.33	0.27	0.39	0.056	77	0.40	42	56	-	20	25.00	80.11
2200-2246	8.12	12.6	0.17	0.40	0.020	16	-	11	36	1.5	9.1	50.01	161.66
2246-2336	7.68	11.8	0.19	0.42	0.030	47	0.36	18	40	-	14	25.00	80.02
2336-2462	7.77	11.9	0.18	0.40	0.035	51	0.043	18	40	-	17	50.01	160.33
2462-2480	5.09	8.06	0.24	0.28	0.047	71	0.11	94	48	2.3	17	50.02	160.00
2480-2606	7.85	12.2	0.18	0.39	0.047	53	-	10	37	-	24	50.00	161.25
2606-2693	2.95	4.77	0.22	0.33	0.050	258	0.049	41	43	-	18	50.08	160.29
2693-2779	8.76	13.4	0.13	0.29	0.031	25	0.38	6.9	23	-	9.4	25.00	80.10
2779-2826	3.76	6.06	0.16	0.28	0.036	192	0.027	37	33	1.7	15	50.00	160.25
2826-3053	7.19	11.0	0.19	0.43	0.012	31	-	14	60	1.2	13	50.13	160.83
3053-3167	6.82	10.3	0.20	0.45	0.007	24	-	15	44	1.3	9.1	50.02	160.19
3167-3224	3.11	4.77	0.15	0.24	0.012	64	-	28	71	-	8.7	50.05	160.38
3224-3355	3.46	5.32	0.11	0.14	0.015	52	-	17	82	1.2	9.0	50.03	161.05
3355-3614	6.63	10.0	0.19	0.43	0.011	58	-	16	78	-	10	50.36	159.76
3667-3705	3.16	4.82	0.07	0.04	0.018	88	-	28	68	1.3	6.4	49.48	176.64
3846-4104	6.47	9.71	0.17	0.40	0.009	38	-	19	67	1.1	7.1	50.02	160.23
4104-4205	3.16	4.79	0.07	0.10	0.014	64	-	20	77	1.8	6.4	50.03	160.37
4205-4324	6.90	10.5	0.19	0.43	0.007	27	-	19	67	1.1	6.2	50.66	159.52
4324-4356	3.80	5.82	0.16	0.34	0.009	32	0.030	21	45	1.2	5.1	50.04	159.97
4356-4519	7.41	11.2	0.18	0.42	0.005	20	-	18	55	1.4	5.7	50.03	160.37
4519-4562	3.24	5.41	0.04	0.04	0.008	30	0.030	9.4	71	1.2	5.3	50.09	160.33
4562-4642	8.38	12.4	0.17	0.41	0.011	32	-	9.8	42	1.1	8.9	50.05	160.29
4642-4726	8.20	12.4	0.16	0.40	0.021	20	-	13	39	1.4	8.3	50.50	160.11
4726-4813	7.46	11.3	0.18	0.43	0.045	42	-	12	49	1.5	12	50.00	160.23
4813-4929	7.28	11.0	0.18	0.44	0.015	32	-	13	49	1.2	10	50.08	160.61

*Penn Schloemann, Analytical Laboratories

**Fe less than 0.01 ppm

***I less than 1 ppm

PORT RICHMOND DEPOSIT-CANSO-BRAS D'OR AREA

Table 7-10. Analyses of salt core samples, drillhole PM-1, Port Richmond deposit (Rowe, 1966).

Sample Interval (feet)	Water Insoluble (%)	Specific Gravity (%)	Sodium Chloride (%)	Calcium (ppm)	Sulfate (ppm)	Potassium (ppm)	Magnesium (ppm)
926.5 - 939.5	3.54	1.203	25.85	830	2050	36	2.5
1038.5 -1045.5	50.22	1.118	15.10	1870	5070	26	5.1
1056.5 -1065.5	31.48	1.155	20.05	1520	4100	38	1.9
1065.5 -1074.5	34.83	1.152	19.47	1562	4100	38.5	1.9
1074.5 -1083.5	58.60	1.090	11.68	2290	5704	25	1.2
1083.5 -1092.5	61.96	1.065	8.07	2050	5470	19	1.9
1092.5 -1101.5	57.88	1.097	12.56	2051	5400	30	1.9
1101.5 -1105.5	36.31	1.146	18.90	2000	4490	46.5	2.7
1105.5 -1115.5	40.50	1.137	17.56	1950	4950	50	2.3
1115.5 -1125.5	39.18	1.140	18.20	2070	4800	58	4.0
1125.5 -1135.5	32.90	1.151	19.48	1650	4510	52	5.2
1135.5 -1145.5	36.68	1.146	18.60	2070	4700	56	1.0
1145.5 -1155.5	38.80	1.141	18.35	1800	4780	34	1.8
1370 -1381	9.17	1.200	25.75	959	2547	5.5	6.2
1381 -1392	2.72	1.202	25.90	850	2450	71	17
1392 -1403	5.28	1.202	25.98	960	2750	60	2.5
1451.5 -1461.5	5.35	1.202	25.89	981	2676	22	1.5
1461.5 -1471.5	6.83	1.202	25.95	1000	2600	44	1.0
1471.5 -1481.5	9.57	1.202	25.90	1167	2950	22	1.9
1481.5 -1493	24.85	1.165	22.15	1500	3650	13	6.2
1507.25-1513	12.75	1.195	25.30	1300	2860	36	5.0
1514 -1524	10.60	1.197	25.60	960	2600	21	2.5
1524 -1534	3.36	1.202	25.97	790	2150	22	1.3
1534 -1543.5	8.70	1.201	25.85	982	2736	21	2.5
1547 -1556.2	27.00	1.170	22.68	1530	3390	49	8.6
1637 -1647	34.25	1.164	20.90	1632	3661	70.5	16
1647 -1657	10.36	1.201	25.95	849	2338	34	4.6
1657 -1667	20.35	1.189	24.47	883	2290	53	9.5
1667 -1677	4.63	1.203	25.95	939	2453	41	2.5
1677 -1687	4.56	1.203	25.98	835	2200	34	2.1
1687 -1697	2.69	1.203	25.97	750	2200	29	2.0
1697 -1707	2.45	1.203	25.97	790	2450	28	6.7
1707 -1717	6.78	1.201	25.93	870	2080	35	5.0
1717 -1729	18.91	1.189	24.80	1051	2386	19	13.5
1729 -1740.5	19.18	1.184	24.28	1050	2358	46	12
1815 -1818.75	9.37	1.202	25.92	998	2650	29.8	2.5
1822.3 -1818.3	18.34	1.186	24.2	1265	3150	33	5.1
1838.2 -1851	7.34	1.202	25.95	875	2400	21	2.5
1851 -1863.9	17.88	1.187	24.20	1160	2822	29	2.9
1968.8 -1977.8	2.48	1.202	25.91	956	2734	28	2.1
1977.8 -1986.8	1.57	1.201	25.98	791	2220	41	2.1
1986.8 -1995.8	9.25	1.201	25.93	1000	2847	42	3.8
1995.8 -2005.5	3.02	1.203	25.92	946	2437	29	1.7

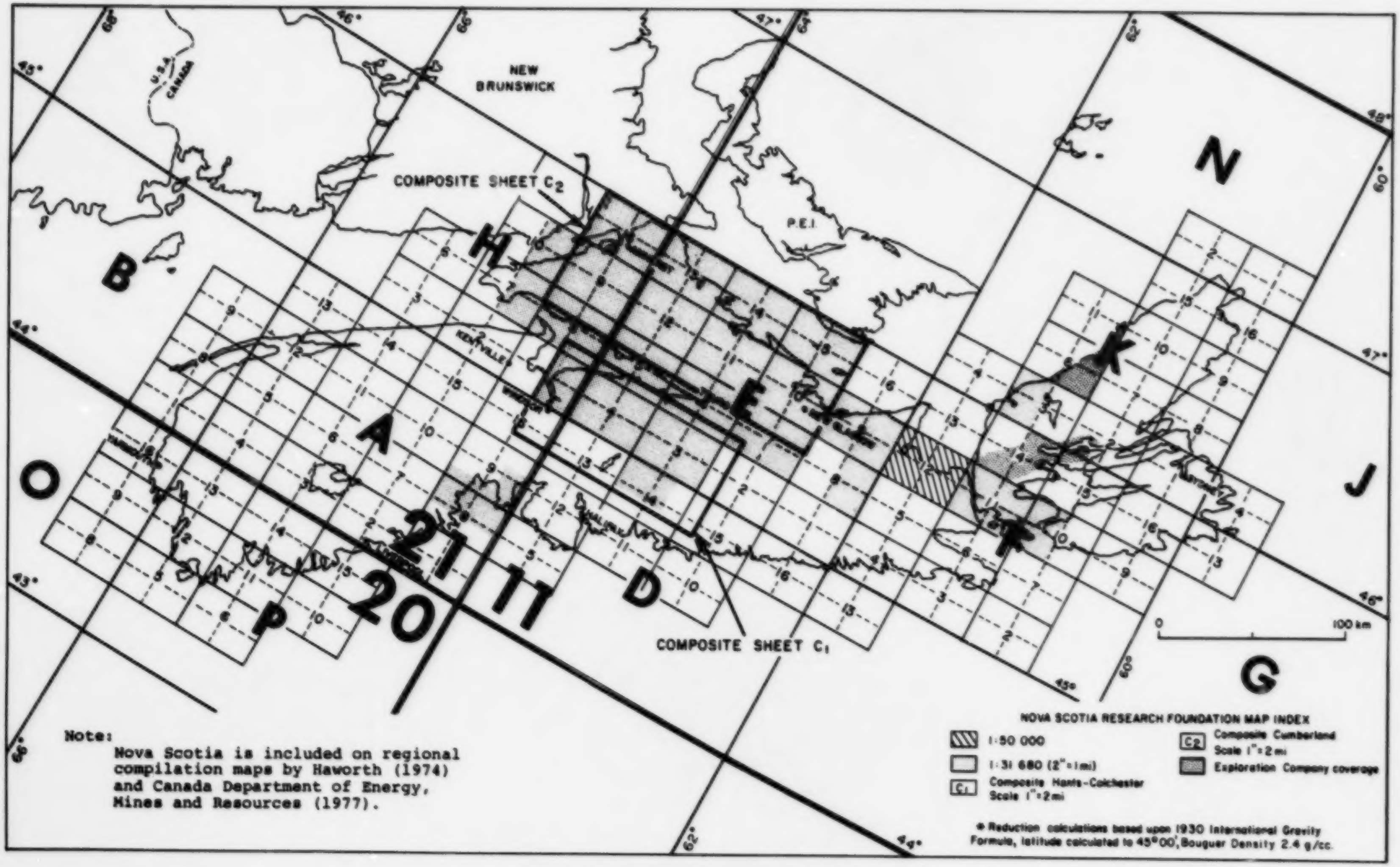
APPENDIX 3

SALT PRODUCTION
IN
NOVA SCOTIA

YEAR	MALAGASH (tons)	NAPPAN (tons)	PUGWASH (tons)
1920	3,095		
1921	2,606		
1922	5,250		
1923	3,911		
1924	5,239		
1925	6,249		
1926	7,985		
1927	12,491		
1928	19,671		
1929	30,625		
1930	25,703		
1931	25,951		
1932	29,082		
1933	34,005		
1934	45,482		
1935	34,886		
1936	40,586		
1937	47,249		
1938	46,355		
1939	49,318		
1940	44,192		
1941	52,522		
1942	50,791		
1943	44,606		
1944	39,397		
1945	36,120		
1946	40,625		
1947	28,375	22,363	
1948	28,824	34,068	
1949	42,410	42,680	
1950	54,989	46,886	
1951	72,795	54,931	
1952	82,427	55,692	
1953	71,034	60,279	
1954	80,652	66,807	
1955	67,881	75,529	
1956	46,964	87,232	
1957	39,021	85,056	
1958	45,306	81,068	
1959	17,834	83,179	20,791
1960		85,415	78,345
1961		84,806	151,079
1962		93,603	224,057
1963		98,962	264,549
1964		97,029	357,423
1965		107,418	339,406
1966		112,046	365,343
1967		108,366	385,752
1968		111,713	391,574
1969		104,242	465,774
1970		106,046	587,744
1971		96,333	735,685
1972		96,396	768,446
1973		108,619	683,219
1974		103,821	732,038
1975		97,485	810,676
1976		92,938	927,236
1977		96,500	906,786
1978		98,198	907,481
1979		87,979	1,177,365
1980		105,369	998,141
1981		86,598	918,373
1982		78,569	1,153,431
1983		70,780	726,440
1984		63,171	762,696

APPENDIX 4

INDEX MAP OF GRAVITY SURVEY COVERAGE IN NOVA SCOTIA


NEW BRUNSWICK
U.S.A.
CANADA
P.E.I.
COMPOSITE SHEET C₂
COMPOSITE SHEET C₁
KENTVILLE
B
H
N
K
E
A
O
J
D
P
G
21
20
11
45°
46°
47°
48°
44°
43°
66°
64°
62°
60°
0
100 km
NOVA SCOTIA RESEARCH FOUNDATION MAP INDEX
1:50 000
1:31 680 (2" = 1 mi)
C₁ Composite Hants-Colchester Scale 1" = 2 mi
C₂ Composite Cumberland Scale 1" = 2 mi
Exploration Company coverage
* Reduction calculations based upon 1930 International Gravity Formula, latitude calculated to 45°00', Bouguer Density 2.4 g/cc.

Note:

Nova Scotia is included on regional compilation maps by Haworth (1974) and Canada Department of Energy, Mines and Resources (1977).

Index of gravity maps of Nova Scotia.

APPENDIX 5

A PHOTOGRAPHIC HISTORY OF SALT AND POTASH EXPLORATION AND MINING IN NOVA SCOTIA

The first rock salt mined in Canada was hoisted at the Malagash Mine, Cumberland County, Nova Scotia on September 2, 1918. Small quantities of potash were produced from this mine beginning in 1921 and represented the first documentation of the presence of potash in the Windsor Group evaporites of Atlantic Canada.

Ship loading pier on Tatamagouche Bay, Malagash Salt Company Limited.

Surface plant Malagash Salt Company Limited, Malagash Mine.

No. 5 Level West, Lucas Seam, Malagash Mine, 1950.

No. 5 Level West, Lucas Seam, Malagash Mine, 1950.

Drill setup used to drill blasting holes in the Malagash Mine.

Undercutting a mine face (stope and level unknown) Malagash Mine (courtesy Reid Picture and Equipment Service).

Solution mining stope, Malagash Mine.

Solution mining stope after brine was pumped out in Malagash Mine. Note the relief on the rock surfaces produced by the different solubility of the salt layers.

Contorted banded salt in mine face, Malagash Mine. The exact location is uncertain.

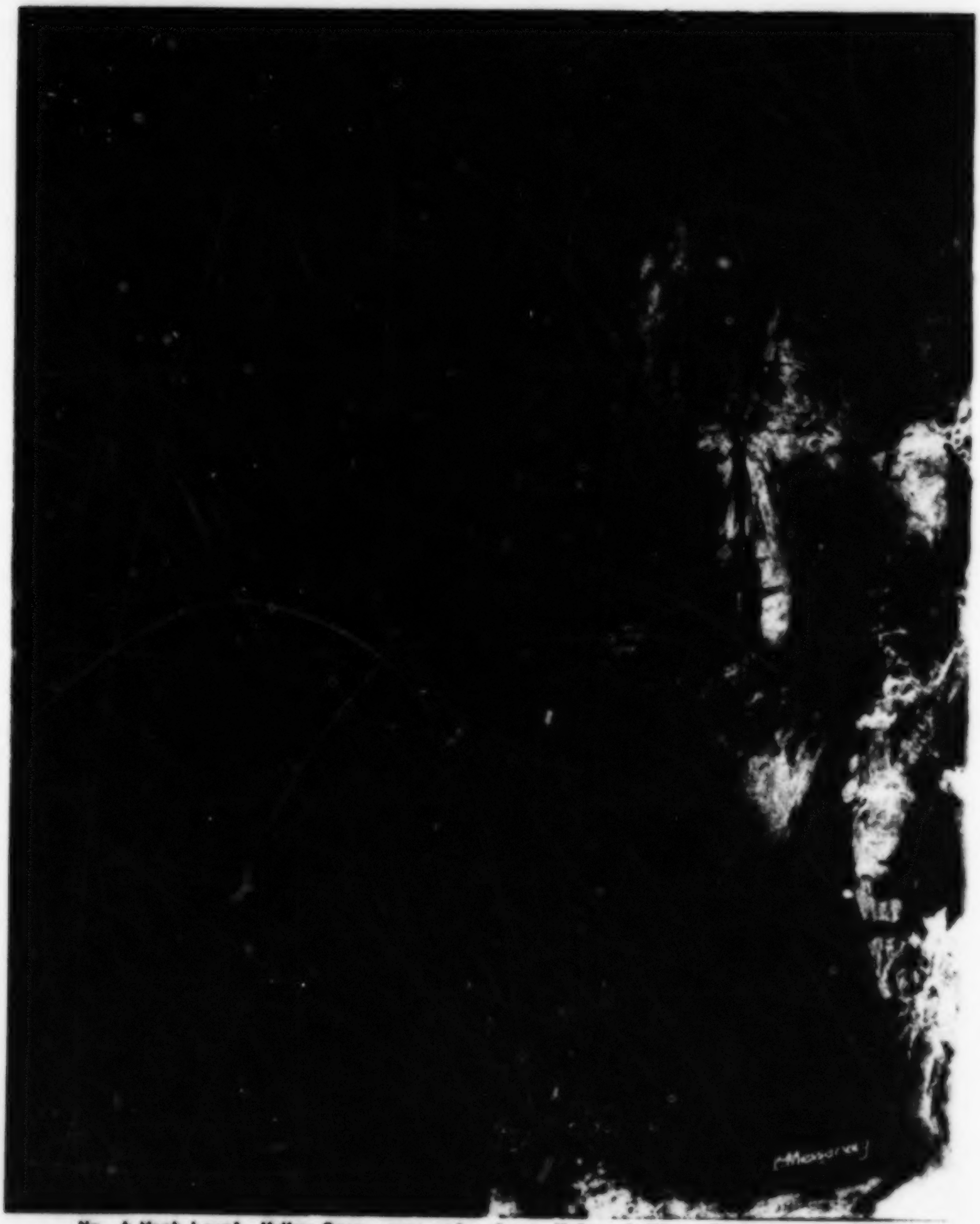
Stope in McKay Seam, Malagash Mine. The location is uncertain (Circa 1925).

Stope on No. 4 level, Malagash Mine.

McKay Seam, face of No. 4 East Level, 300 feet from slope, Malagash Mine, November 20, 1929.

McKay Seam No. 1 Level, 600 feet from shaft, Malagash Mine, November 20, 1929.

No. 4 East Level, McKay Seam, 150 feet from slope, Malagash Mine, September 17, 1929.

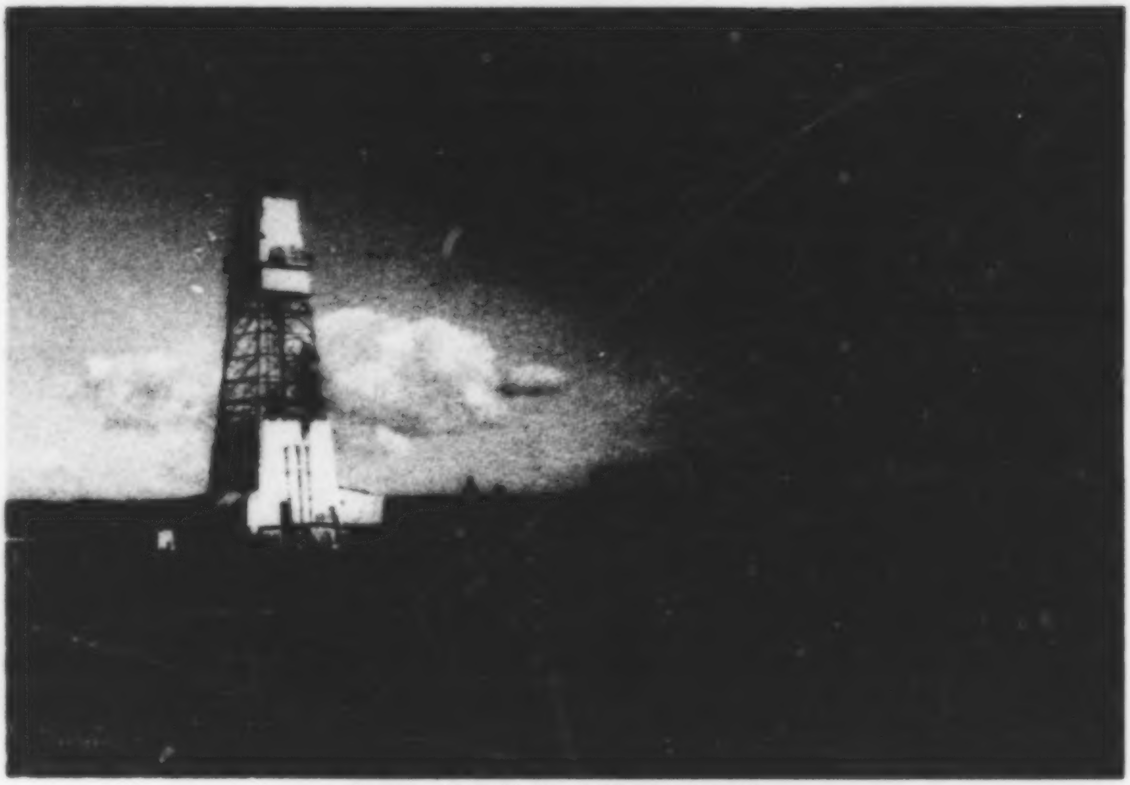


No. 4 West Level, McKay Seam, near main slope, Malagash Mine, September 17, 1929.

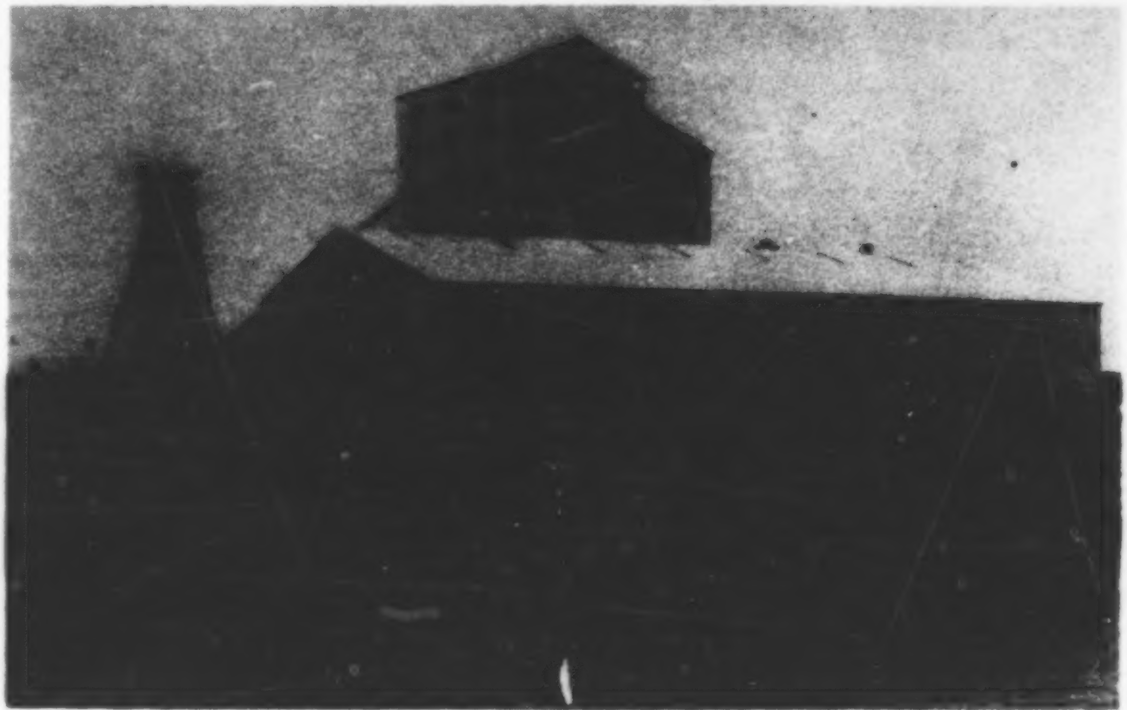
Diamond-drilling at face of Lucas Seam, No. 3 West Level, 500 feet from main slope, Malagash Mine, November 20, 1929.

Domtar Sifto Salt Division brining plant at Nappan, Cumberland County, Nova Scotia (1980).

Salt production plant, Maritime Industries Limited, Nappan.



Sunoco oil well No. 1 Nappan deposit.



No. 1 shaft head frame and processing buildings, Pugwash Mine (NSIS).

No. 1 shaft head frame and processing buildings, Pugwash Mine (NSIS).

Canadian Salt Company Limited, Pugwash Mine, No. 1 head frame (left), No. 2 head frame (centre), Pugwash, Nova Scotia (October, 1980).

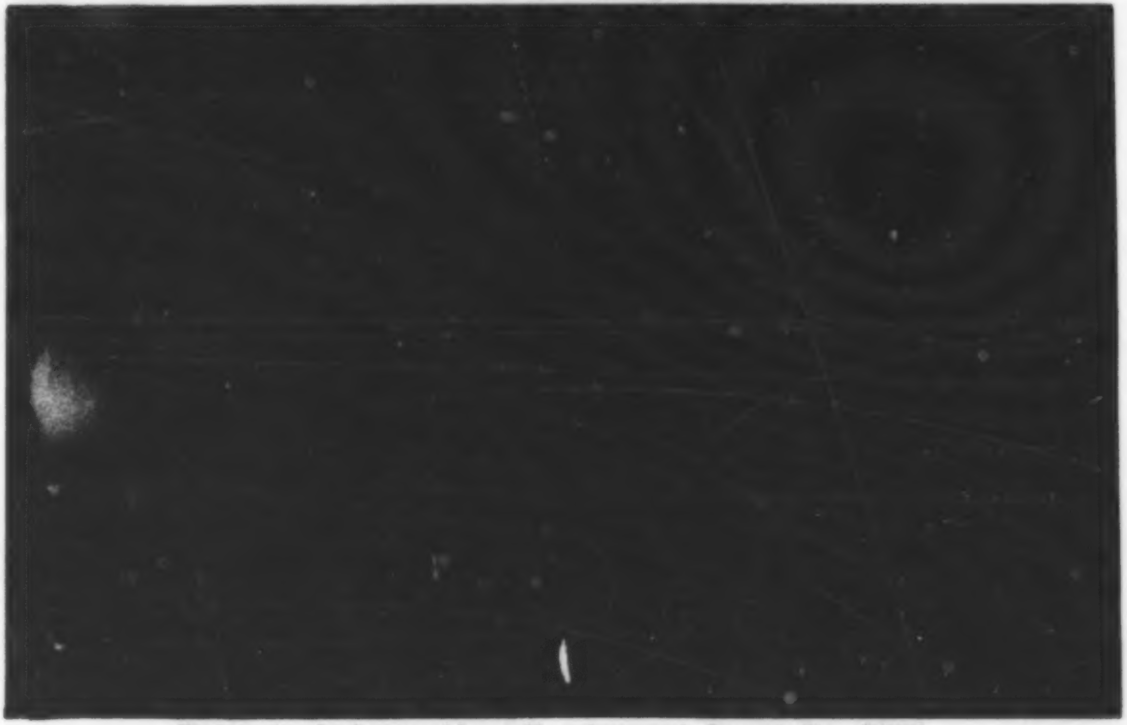
Pubwash Mine, Pugwash, Nova Scotia, No. 2 head frame (left) (October, 1980).

Drill used to drill blast holes in mining face, Pugwash Mine (NSIS).

No. 1 shaft and railway loading facilities, Pugwash Mine.

Loading salt into haulage trucks, Pugwash Mine (NSIS).

Undercutting face to be blasted, Pugwash Mine (NSIS).



Haulage trucks transporting salt underground, Pugwash Mine (NSIS).

Haulage trucks unloading into primary crusher, Pugwash Mine (NSIS).

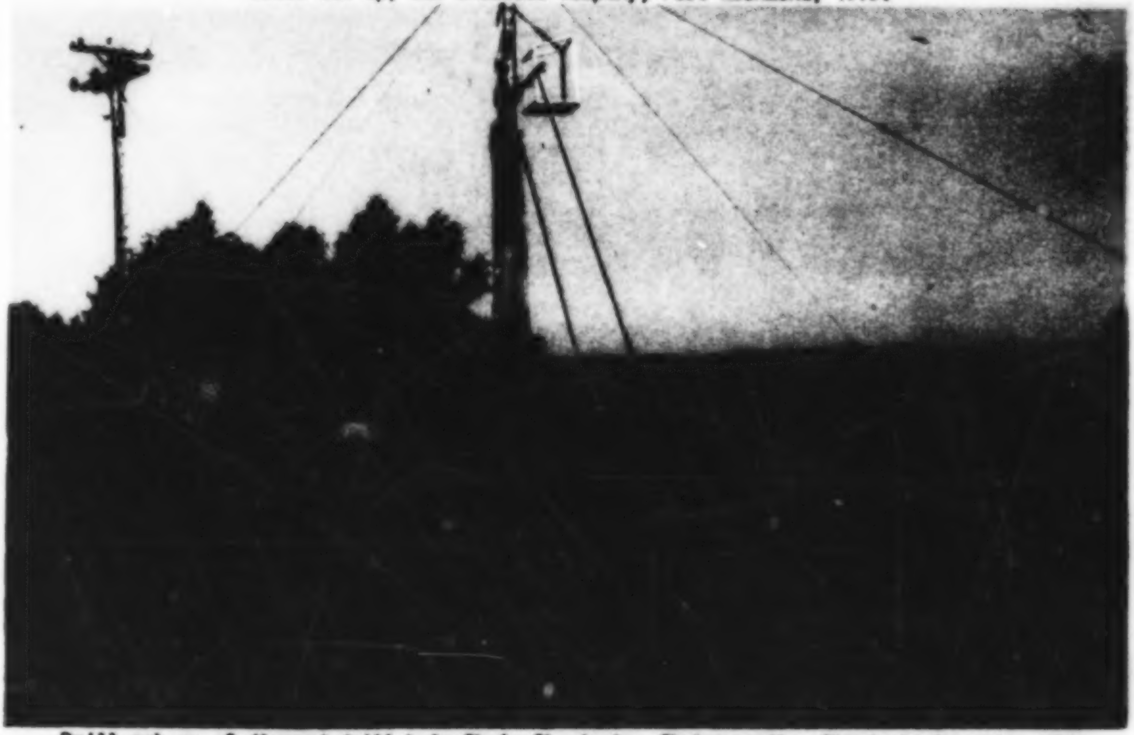
Scaling walls in a room from which a second cut has been removed, Pugwash Mine.

Contorted anhydrite boudins with salt, Pugwash Mine.

Contorted anhydrite boudins in roof view, Pugwash Mine.

Halite megacryst being removed from a potash salt occurrence, Pugwash Mine.

Drill set up, Dow Chemical Company, Port Richmond, 1973.



Drill set up of diamond-drill hole Sb-1, Stewiacke, Shubenacadie, Stewiacke Deposit, 1975.

Drill set up, Wallace Station No. 1, Wallace Station, 1973.

Drill set up, Wallace No. 1, 1966 potash project, Wallace, 1966.

MAP 83-3

LEGEND

(Adapted from the Metallogenic Map of Nova Scotia, A.K. Chatterjee, 1983)

Cretaceous

K	*Clays, silica sand and lignite*

Triassic-Jurassic includes Fundy Group

TJv	*Mafic volcanic rocks*
TJs	*Shale, siltstone and sandstone*

Late Carboniferous includes Cumberland, Pictou, Stellarton and Morien Groups

LC	*Mixed sandstone to shale sequences*

Early to Late Carboniferous includes Canso and Riversdale Groups

E-LC	*Mixed shale to sandstone sequences*

Early Viséan includes Windsor Group

■	*Siltstone, mudstone, shale, sandstone, conglomerate, gypsum, anhydrite, halite, limestone and dolostone*

Early Carboniferous includes Horton Group and *Grantmire Formation* (may include Late Devonian rocks)

ECH	*Conglomerate, sandstone, siltstone and shale*

Devono-Carboniferous includes Fountain Lake Group and *Greville River, Rapid Brook, Nuttby Falls, Murphy Brook, McAdam Lake and Fisset Brook Formations*

DC	*Conglomerate, sandstone, siltstone and volcanic rocks*

Siluro Devonian includes Arisaig Group and *New Canaan, Kentville, White Rock, Portapique River, Wilson Brook, Knoydart, Earltown, Bear Brook, McGillivary Brook and Dunn Point Formations*

SD	*Siltstone, shale, sandstone and volcanic rocks and their metamorphic equivalents*

Cambro-Ordovician includes Meguma, Iron Brook, McDonalds Brook, Bourinot and Kelvin Glen Groups

CO	*Shale, siltstone, sandstone, conglomerate and volcanic rocks and their metamorphic equivalents*

Hadrynian includes George River, Fourchu and Georgeville Groups, and rocks of Mount Thom Complex

Hs	*Shale, siltstone, sandstone, conglomerate and volcanic rocks and their metamorphic equivalents*
Hc	*Limestone, dolostone, sandstone, and shale and their metamorphic equivalents*

INTRUSIVE COMPLEXES

Devono-Carboniferous Intrusive complexes

DCg	*Granodiorite and granite*

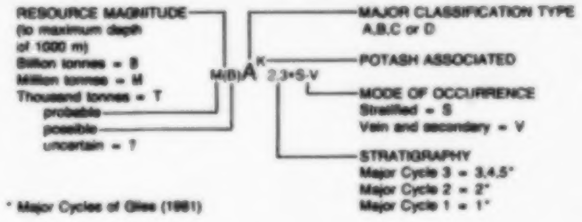
Hadrynian Devonian Intrusive complexes

H-Dg	*Diorite, granodiorite and granite*
H-Db	*Basic and Ultrabasic rocks*

SYMBOLS

Uncomformity	
Normal fault	
Reverse fault	
Thrust fault	
Wrench fault	
Fault	—
Geological boundary	—
Deposit or occurrence name (depth to salt in metres)	Ohio(110 m)
Salt mine, underground (operating)	⚒
Salt mine, underground (abandoned)	⚒
Salt mine, brining (operating)	⚒B
Drill- or borehole intersecting salt, Windsor Group or younger	●0-1
Horton Group salt is also present	⊗
Potash salts present; sylvite-KCl and/or carnallite-$KMgCl_3 \cdot 6H_2O$	K_2O
Salt spring or seepage reported, locations only approximate	*

SALT RESOURCE CLASSIFICATION CODE



* Major Cycles of Giles (1981)

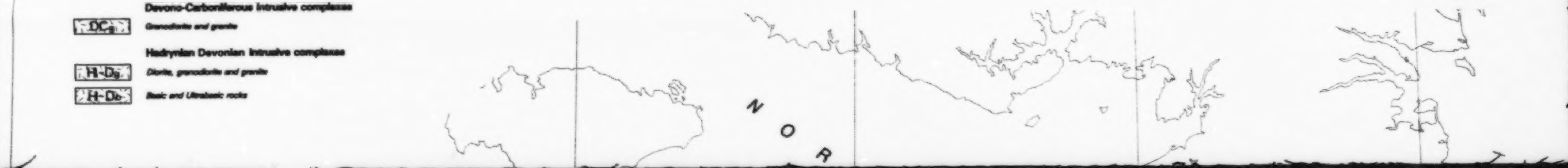
Deposit: geologically defined, significant thickness, typically greater than 100 m, associated with a major Bouguer gravity anomaly (minimum); no consideration given to exploitability factors such as depth, geographic location or purity.

Occurrence: applied to two situations, 1) trace quantities such as veins in enclosing rocks; or 2) thin intersections of veins and impure halite layers (typically less than 10 m). If associated with a Bouguer gravity minimum, certain occurrences have good potential to be upgraded to deposit status with further drilling.

Salt deposits and occurrences of Nova Scotia.

Hants-Colchester Area	Deposit or Occurrence	Structural Type	Major Cycle(s)
Beaver Brook	Deposit	B	1
Clarksville	Occurrence	B-C	5
Falmouth	Occurrence	?	1
Kennetcook	Occurrence	B-C	1
Shubenacadie-Stewiacke	Deposit	A	1,2,5
Stanley	Occurrence	B-C	1
Summerville	Occurrence	Vein	—
Upper Walton River	Occurrence	C	1-2?
Walton	Occurrence	B-C	1-2?
Cumberland Area			
Beckwith	Occurrence	C-D	?
Malagash*	Deposit	D	?
Nappan*	Deposit	D	?
Oxford*	Deposit	D	?
Pugwash*	Deposit	D	?
Roslin	Occurrence	D	?
Antigonish-Mabou Area			
Antigonish	Deposit	B-C	1
James River*	Deposit	B-C	1
Mabou	Deposit	C-D	1-4?
Ohio	Occurrence	A	1
Pomquet River	Occurrence	C	1?
Southside Harbour*	Deposit	B	1
Canso-Bras d'Or Area			
Cleveland*	Deposit	B-C	2-5?
Estmere	Deposit	B-C	2-5?
Kingsville	Deposit	C-D	1-5?
McIntyre Lake*	Deposit	C	1-5?
Malagawatch*	Deposit	C?	1-4
Orangedale*	Deposit	C?	1-4
Port Richmond*	Deposit	C-D?	1-4
Seaview .	Occurrence	C	1?
St. Patricks Channel	Deposit	C	1-4
St. Peters*	Deposit	C	1?
Sydney Area			
Boularderie*	Deposit	A-B	1-2
East Bay	Occurrence	A	1?

* Potash salts reported.

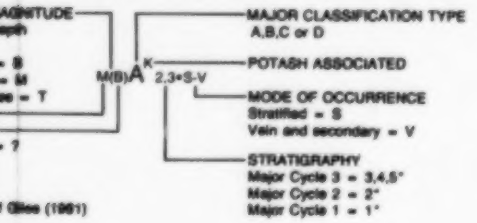


63°30′ 63°00′ 62°30′ 62°00′ 61°30′ 61°00′

SYMBOLS

nity ....
ult ....
ult ....
t ....
ult ....
....
boundary ....
occurrence name (depth to salt in metres) .... Ohio(110 m)
underground (operating) .... ⚒
underground (abandoned) .... ⚒
brining (operating) .... ⚒B
rehole intersecting salt, Windsor Group or younger .... ●O-1
up salt is also present .... ●
s present; sylvite-KCl and/or carnallite-$KMgCl_3 \cdot 6H_2O$ .... K_2O
or seepage reported, locations only approximate .... ✱

SALT RESOURCE CLASSIFICATION CODE


AGNITUDE
pth
= B
= M
e = T
= ?
M(B)A^K 2,3•S-V
MAJOR CLASSIFICATION TYPE
A,B,C or D
POTASH ASSOCIATED
MODE OF OCCURRENCE
Stratified = S
Vein and secondary = V
STRATIGRAPHY
Major Cycle 3 = 3,4,5*
Major Cycle 2 = 2*
Major Cycle 1 = 1*
Giles (1981)

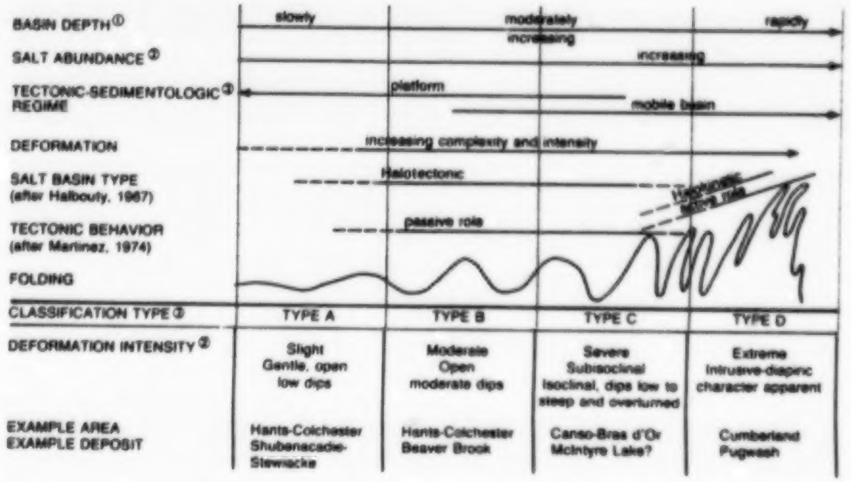
ologically defined, significant thickness, typically greater 100 m, associated with a major Bouguer gravity anomaly mum); no consideration given to exploitability factors such pth, geographic location or purity.
: applied to two situations, 1) trace quantities such as veins closing rocks; or 2) thin intersections of veins and impure layers (typically less than 10 m). If associated with a uer gravity minimum, certain occurrences have good tial to be upgraded to deposit status with further drilling.

Salt deposits and occurrences of Nova Scotia.

Hants-Colchester Area	Deposit or Occurrence	Structural Type	Major Cycle(s)
Beaver Brook	Deposit	B	1
Clarksville	Occurrence	B-C	5
Falmouth	Occurrence	?	1
Kennetcook	Occurrence	B-C	1
Shubenacadie-Stewiacke	Deposit	A	1,2,5
Stanley	Occurrence	B-C	1
Summerville	Occurrence	Vein	—
Upper Walton River	Occurrence	C	1-2?
Walton	Occurrence	B-C	1-2?
Cumberland Area			
Beckwith	Occurrence	C-D	?
Malagash*	Deposit	D	?
Nappan*	Deposit	D	?
Oxford*	Deposit	D	?
Pugwash*	Deposit	D	?
Roslin	Occurrence	D	?
Antigonish-Mabou Area			
Antigonish	Deposit	B-C	1
James River*	Deposit	B-C	1
Mabou	Deposit	C-D	1-4?
Ohio	Occurrence	A	1
Pomquet River	Occurrence	C	1?
Southside Harbour*	Deposit	B	1
Canso-Bras d'Or Area			
Cleveland*	Deposit	B-C	2-5?
Estmere	Deposit	B-C	2-5?
Kingsville	Deposit	C-D	1-5?
McIntyre Lake*	Deposit	C	1-5?
Malagawatch*	Deposit	C?	1-4
Orangedale*	Deposit	C?	1-4
Port Richmond*	Deposit	C-D?	1-4
Seaview .	Occurrence	C	1?
St. Patricks Channel	Deposit	C	1-4
St. Peters*	Deposit	C	1?
Sydney Area			
Boularderie*	Deposit	A-B	1-2
East Bay	Occurrence	A	1?

* Potash salts reported.

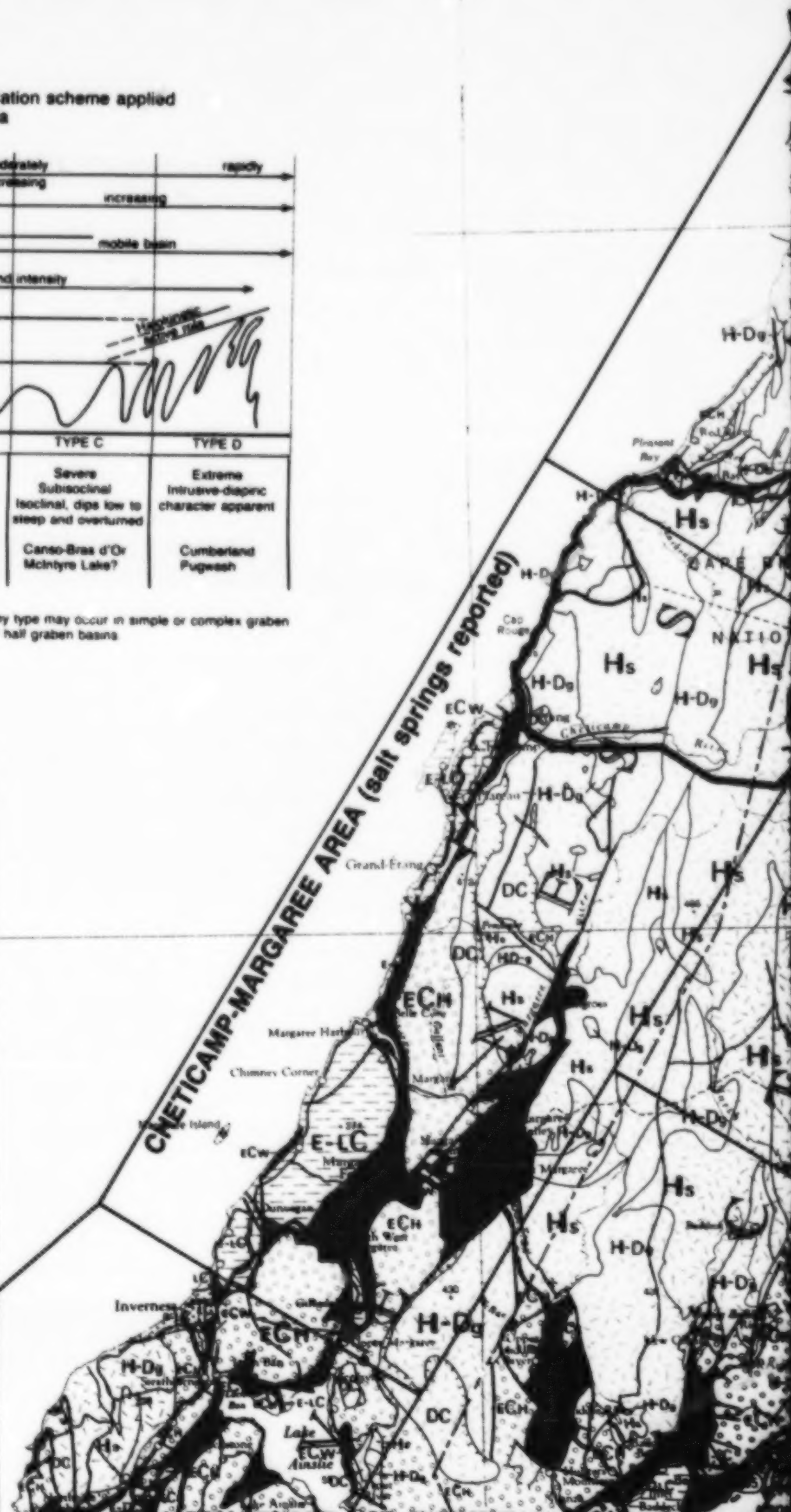
Summary of salt deposit structural classification scheme applied to Windsor Group evaporites in Nova Scotia

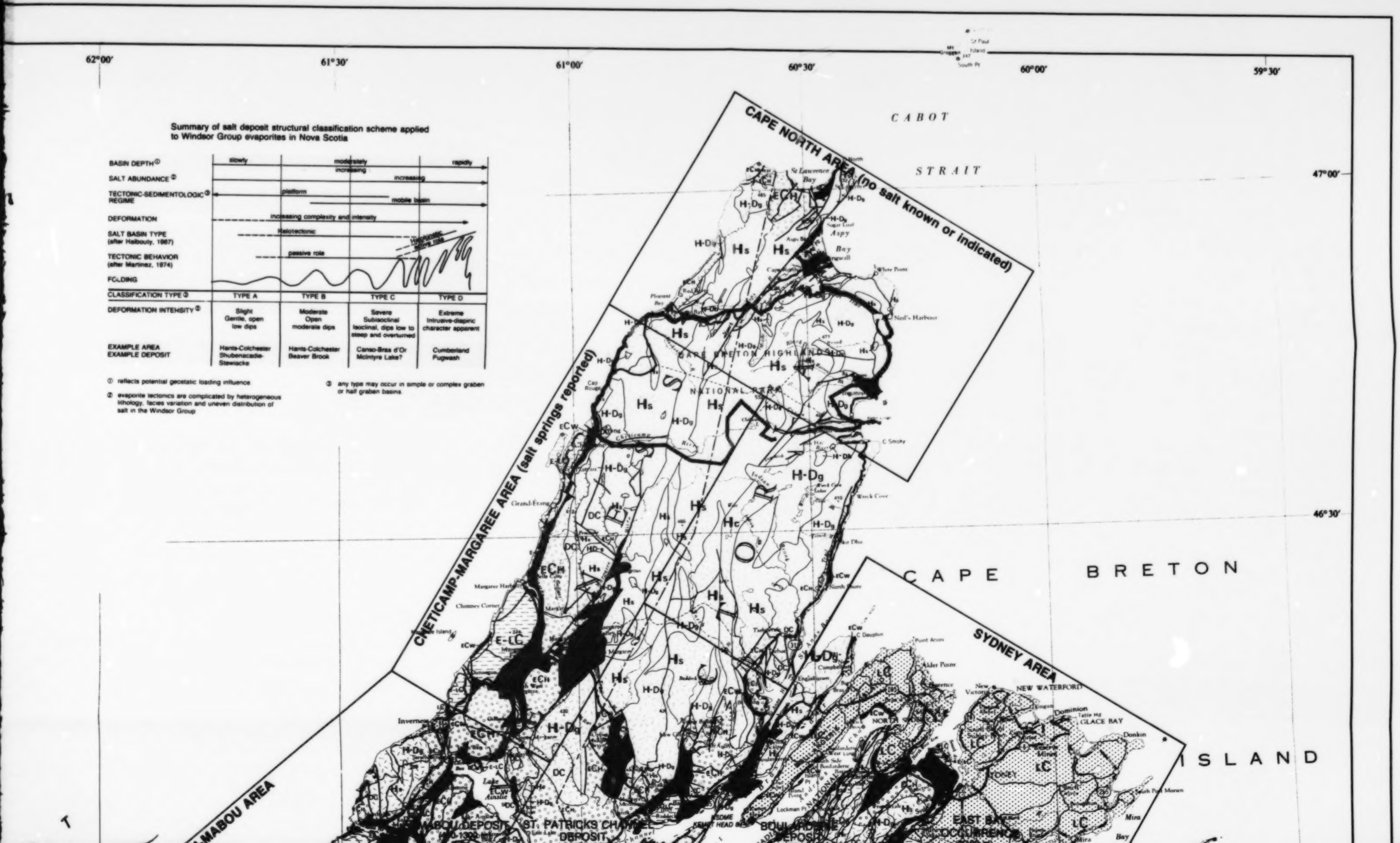

BASIN DEPTH①
slowly
moderately
rapidly
SALT ABUNDANCE ②
increasing
increasing
TECTONIC-SEDIMENTOLOGIC ③ REGIME
platform
mobile basin
DEFORMATION
increasing complexity and intensity
SALT BASIN TYPE (after Halbouty, 1967)
Halotectonic
Hydroplastic
TECTONIC BEHAVIOR (after Martinez, 1974)
passive role
active role
FOLDING
CLASSIFICATION TYPE ③
TYPE A
TYPE B
TYPE C
TYPE D
DEFORMATION INTENSITY ②
Slight Gentle, open low dips
Moderate Open moderate dips
Severe Subisoclinal Isoclinal, dips low to steep and overturned
Extreme Intrusive-diapiric character apparent
EXAMPLE AREA
EXAMPLE DEPOSIT
Hants-Colchester Shubenacadie-Stewiacke
Hants-Colchester Beaver Brook
Canso-Bras d'Or McIntyre Lake?
Cumberland Pugwash

① reflects potential geostatic loading influence

② evaporite tectonics are complicated by heterogeneous lithology, facies variation and uneven distribution of salt in the Windsor Group

③ any type may occur in simple or complex graben or half graben basins


CHETICAMP-MARGAREE AREA (salt springs reported)
Grand Etang
Margaree Harbour
Chimney Corner
Inverness
Hs
H-Ds
ECH
E-LC
DC
eCw
NATIO


62° 00′
61° 30′
61° 00′
60° 30′
60° 00′
59° 30′
47° 00′
46° 30′
St Paul Island
South Pt
CABOT STRAIT
CAPE NORTH AREA (no salt known or indicated)
CHETICAMP-MARGAREE AREA (salt springs reported)
SYDNEY AREA
MABOU AREA
CAPE BRETON ISLAND
CAPE BRETON HIGHLANDS NATIONAL PARK
St Lawrence Bay
Aspy Bay
Neil's Harbour
C Smoky
Wreck Cove
Grand-Étang
Margaree Harbour
Chimney Corner
Inverness
Lake Ainslie
Pleasant Bay
Cap Rouge
Point Aconi
Alder Point
New Victoria
NEW WATERFORD
Dominion
GLACE BAY
Donkin
Mira Bay
MABOU DEPOSIT
ST. PATRICKS CHANNEL DEPOSIT
BOULARDERIE DEPOSIT
EAST BAY OCCURRENCE
KEMPT HEAD
Hs
H-Dg
Hc
DC
ECH
ECw
E-LC
LC
BASIN DEPTH①
slowly
moderately
rapidly
increasing
SALT ABUNDANCE②
increasing
TECTONIC-SEDIMENTOLOGIC REGIME③
platform
mobile basin
DEFORMATION
increasing complexity and intensity
SALT BASIN TYPE (after Halbouty, 1967)
Halotectonic
Halokinetic
TECTONIC BEHAVIOR (after Martinez, 1974)
passive role
active role
FOLDING

Summary of salt deposit structural classification scheme applied to Windsor Group evaporites in Nova Scotia

CLASSIFICATION TYPE③	TYPE A	TYPE B	TYPE C	TYPE D
DEFORMATION INTENSITY③	Slight Gentle, open low dips	Moderate Open moderate dips	Severe Subisoclinal Isoclinal, dips low to steep and overturned	Extreme Intrusive-diapiric character apparent
EXAMPLE AREA EXAMPLE DEPOSIT	Hants-Colchester Shubenacadie-Stewiacke	Hants-Colchester Beaver Brook	Canso-Bras d'Or McIntyre Lake?	Cumberland Pugwash

① reflects potential geostatic loading influence

② evaporite tectonics are complicated by heterogeneous lithology, facies variation and uneven distribution of salt in the Windsor Group

③ any type may occur in simple or complex graben or half graben basins *sandstone, conglomerate and volcanic rocks and their metamorphic equivalents*

Hadrynian includes George River, Fourchu and Georgeville Groups, and rocks of Mount Thom Complex

Hs	*Shale, siltstone, sandstone, conglomerate and volcanic rocks and their metamorphic equivalents*
Hc	*Limestone, dolostone, sandstone, and shale and their metamorphic equivalents*

INTRUSIVE COMPLEXES

Devono-Carboniferous intrusive complexes

DC_g	*Granodiorite and granite*

Hadrynian Devonian intrusive complexes

$H\text{-}D_g$	*Diorite, granodiorite and granite*
$H\text{-}D_b$	*Basic and Ultrabasic rocks*

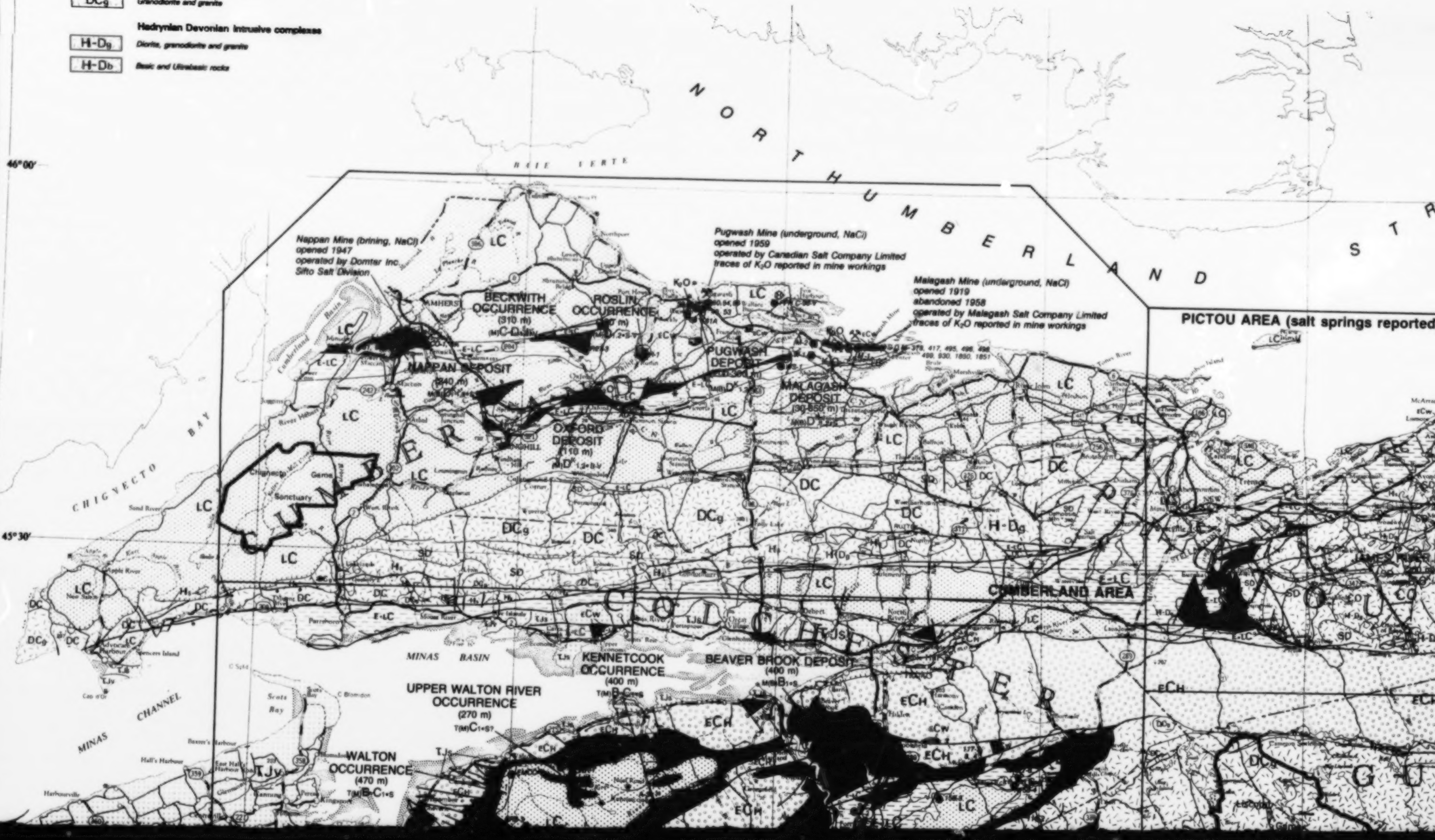
potential to be upgraded to deposit status with further drilling.

Port Richmond	Deposit	C-D?	1-4
Seaview	Occurrence	C	1?
St. Patricks Channel	Deposit	C	1-4
St. Peters*	Deposit	C	1?

Sydney Area

Boularderie*	Deposit	A-B	1-2
East Bay	Occurrence	A	1?

* Potash salts reported.

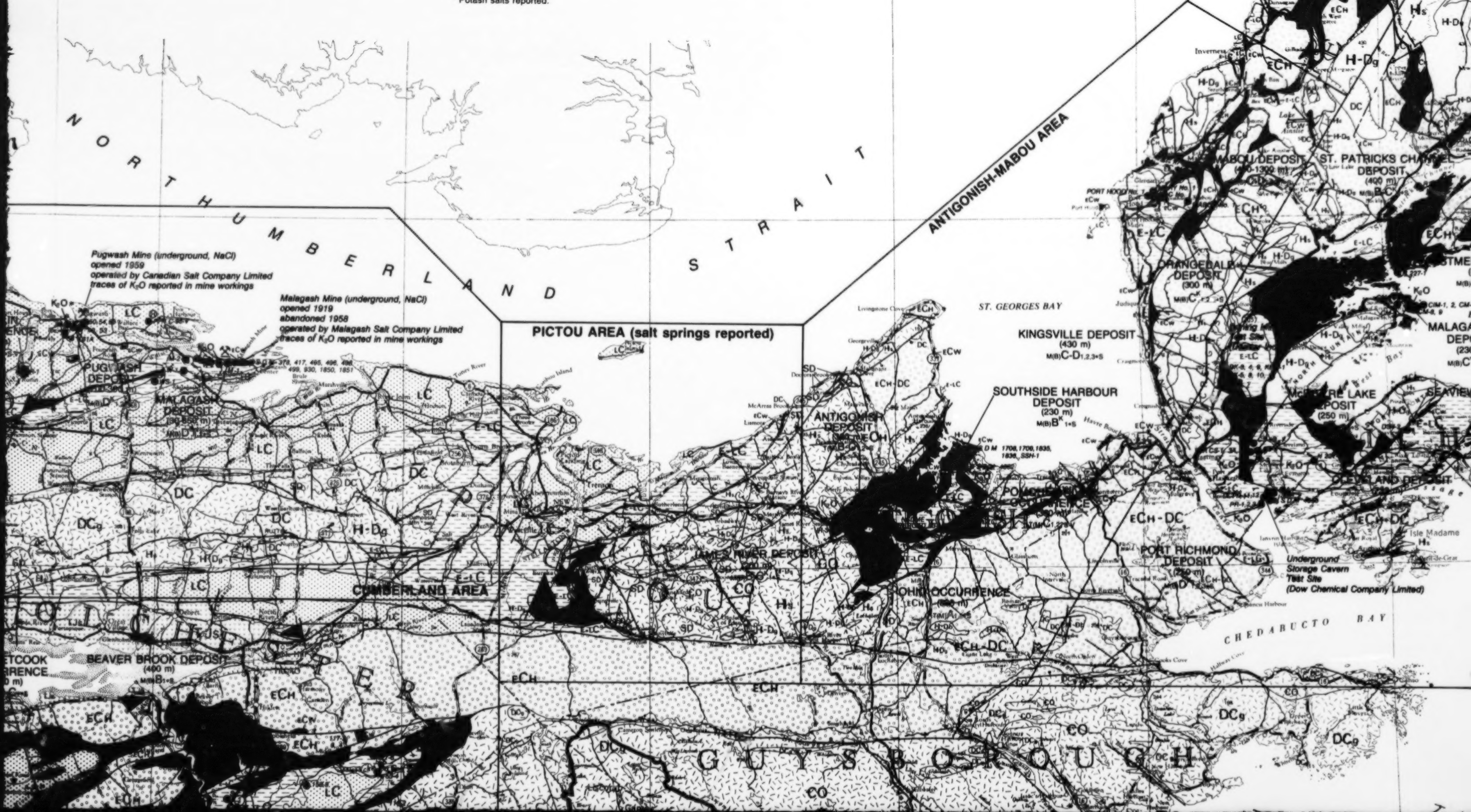


46°00′
45°30′
BAIE VERTE
NORTHUMBERLAND STRAIT
CHIGNECTO BAY
MINAS BASIN
MINAS CHANNEL
Cumberland Basin
Scots Bay
Nappan Mine (brining, NaCl)
opened 1947
operated by Domtar Inc.
Sifto Salt Division
Pugwash Mine (underground, NaCl)
opened 1959
operated by Canadian Salt Company Limited
traces of K_2O reported in mine workings
Malagash Mine (underground, NaCl)
opened 1919
abandoned 1958
operated by Malagash Salt Company Limited
traces of K_2O reported in mine workings
K_2O
BECKWITH OCCURRENCE
(310 m)
ROSLIN OCCURRENCE
NAPPAN DEPOSIT
(240 m)
PUGWASH DEPOSIT
MALAGASH DEPOSIT
(30-550 m)
OXFORD DEPOSIT
(110 m)
378, 417, 495, 496, 498
499, 930, 1850, 1851
PICTOU AREA (salt springs reported
CUMBERLAND AREA
KENNETCOOK OCCURRENCE
(400 m)
BEAVER BROOK DEPOSIT
(400 m)
UPPER WALTON RIVER OCCURRENCE
(270 m)
WALTON OCCURRENCE
(470 m)
AMHERST
Chignecto
Game
Sanctuary
Parrsboro
C Blomidon
LC
E-LC
DC
DC_g
SD
$H\text{-}D_g$
Hs
eCw
ECH
TJs
TJv
CUMBERLAND
COLCHESTER

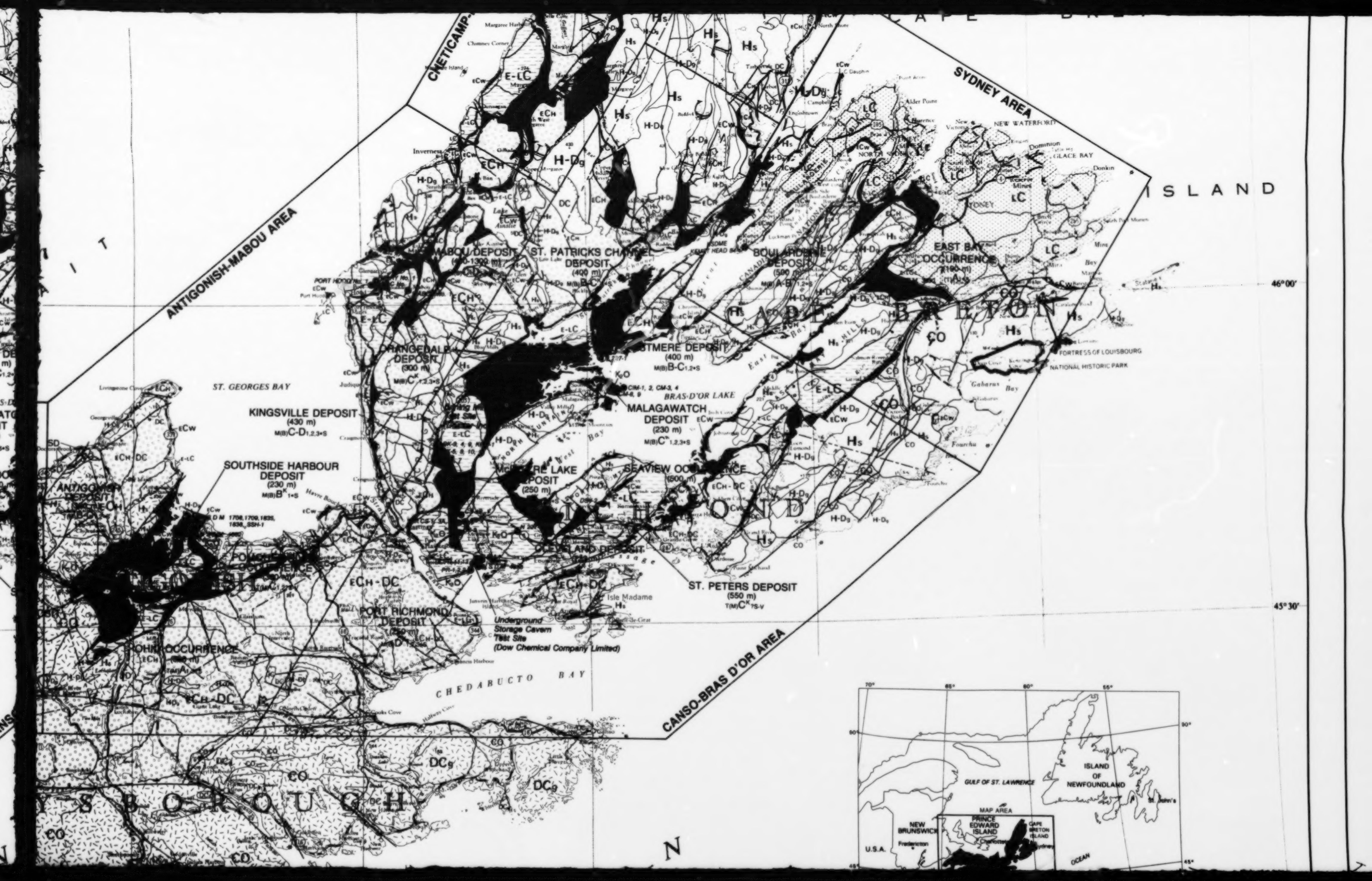
halite layers (typically less than 10 m). If associated with a Bouguer gravity minimum, certain occurrences have good potential to be upgraded to deposit status with further drilling.

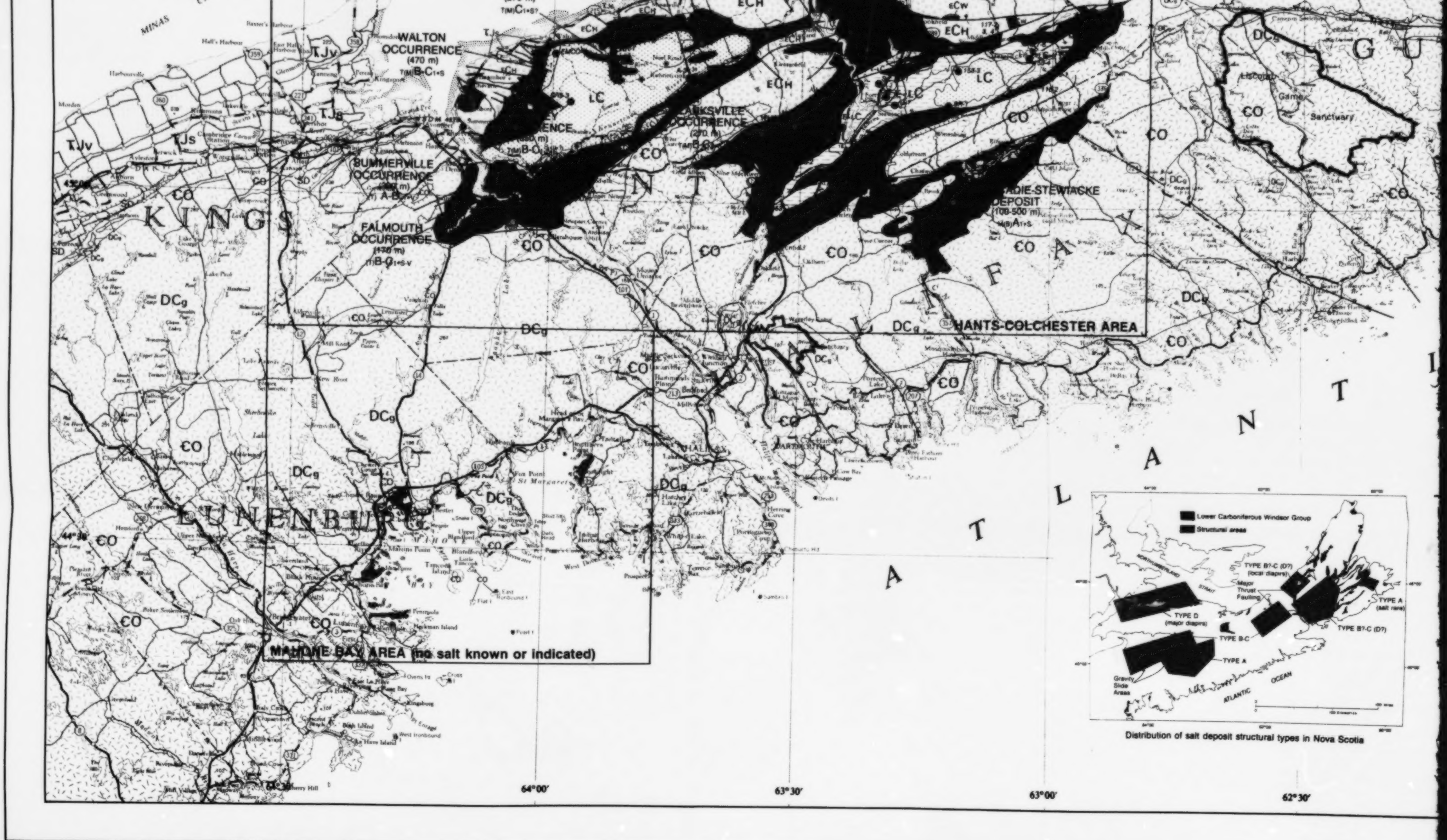
Orangedale	Deposit	C?	1-4
Port Richmond*	Deposit	C-D?	1-4
Seaview	Occurrence	C	1?
St. Patricks Channel	Deposit	C	1-4
St. Peters*	Deposit	C	1?
Sydney Area			
Boularderie*	Deposit	A-B	1-2
East Bay	Occurrence	A	1?

* Potash salts reported.



NORTHUMBERLAND STRAIT
ANTIGONISH-MABOU AREA
CHETICAMP-MA
PICTOU AREA (salt springs reported)
CUMBERLAND AREA
Pugwash Mine (underground, NaCl)
opened 1959
operated by Canadian Salt Company Limited
traces of K₂O reported in mine workings
Malagash Mine (underground, NaCl)
opened 1919
abandoned 1958
operated by Malagash Salt Company Limited
traces of K₂O reported in mine workings
PUGWASH DEPOSIT
MALAGASH DEPOSIT
BEAVER BROOK DEPOSIT
(400 m)
JAMES RIVER DEPOSIT
ANTIGONISH DEPOSIT
OHIO OCCURRENCE
POMQUET OCCURRENCE
ST. GEORGES BAY
KINGSVILLE DEPOSIT
(430 m)
SOUTHSIDE HARBOUR DEPOSIT
(230 m)
PORT RICHMOND DEPOSIT
ORANGEDALE DEPOSIT
(300 m)
MABOU DEPOSIT
ST. PATRICKS CHANNEL DEPOSIT
(400 m)
McINTYRE LAKE DEPOSIT
(250 m)
CLEVELAND DEPOSIT
SEAVIEW
MALAGA
Underground Storage Cavern Test Site
(Dow Chemical Company Limited)
CHEDABUCTO BAY
Isle Madame
GUYSBOROUGH
COLCHESTER
PICTOU
Inverness


CHETICAMP
SYDNEY AREA
ANTIGONISH-MABOU AREA
CANSO-BRAS D'OR AREA
CAPE BRETON
ISLAND
MABOU DEPOSIT
(400-1300 m)
ST. PATRICKS CHANNEL DEPOSIT
(400 m)
M(B)B-C
BOULARDERIE DEPOSIT
(500 m)
M(B)A-B
EAST BAY OCCURRENCE
(190 m)
ORANGEDALE DEPOSIT
(300 m)
M(B)C 1,2,3•S
KINGSVILLE DEPOSIT
(430 m)
M(B)C-D 1,2,3•S
WESTMERE DEPOSIT
(400 m)
M(B)B-C 1,2•S
MALAGAWATCH DEPOSIT
(230 m)
M(B)C 1,2,3•S
SOUTHSIDE HARBOUR DEPOSIT
(230 m)
M(B)B 1•S
McINTYRE LAKE DEPOSIT
(250 m)
SEAVIEW OCCURRENCE
(500 m)
ST. PETERS DEPOSIT
(550 m)
T(M)C ?S-V
PORT RICHMOND DEPOSIT
FLAT LAND DEPOSIT
Underground Storage Cavern Test Site
(Dow Chemical Company Limited)
ST. GEORGES BAY
BRAS D'OR LAKE
CHEDABUCTO BAY
RICHMOND
GUYSBOROUGH
FORTRESS OF LOUISBOURG
NATIONAL HISTORIC PARK
Gabarus Bay
Inverness
Port Hood
Judique
Isle Madame
NEW WATERFORD
GLACE BAY
SYDNEY
Alder Point
Donkin
46°00'
45°30'
GULF OF ST. LAWRENCE
ISLAND OF NEWFOUNDLAND
St. John's
MAP AREA
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
NEW BRUNSWICK
Fredericton
U.S.A.
OCEAN
70°
65°
60°
55°
50°
45°

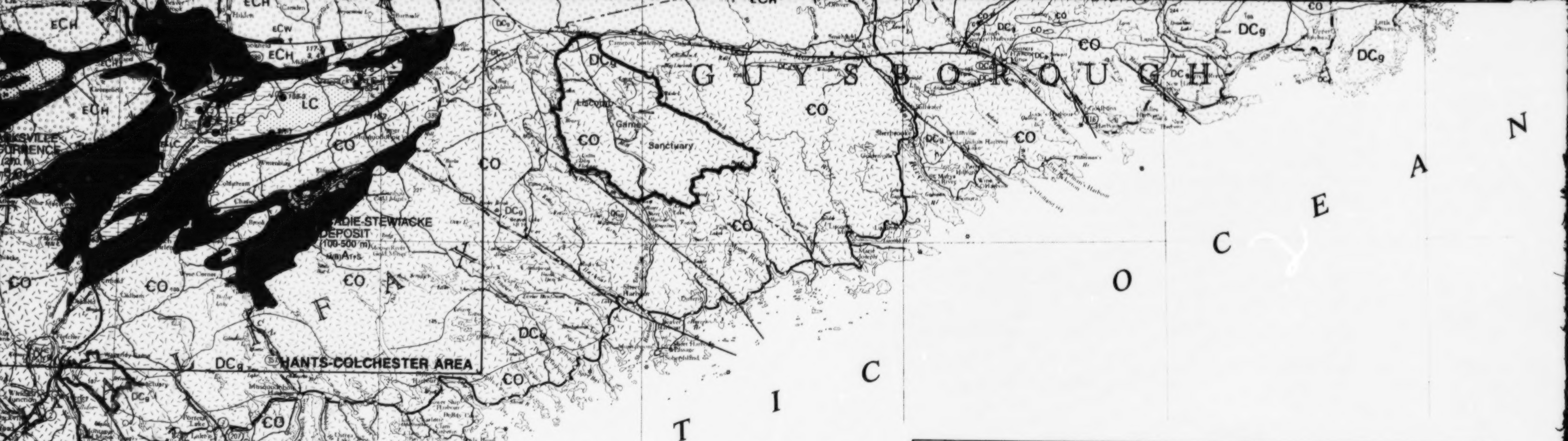


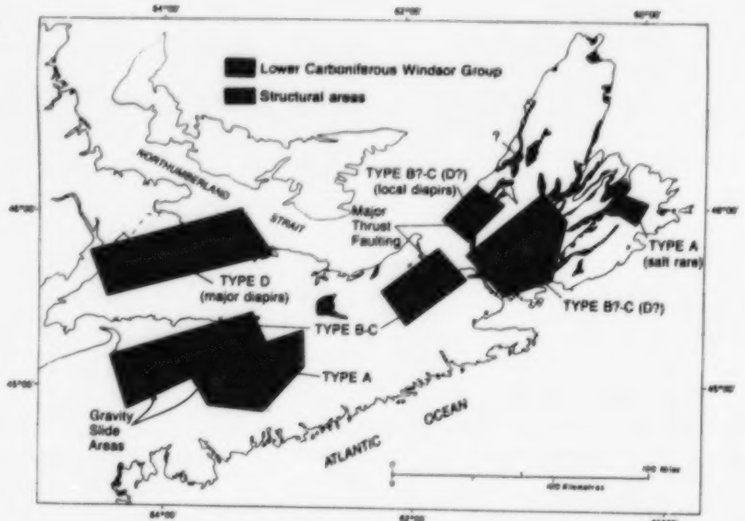
MINAS
WALTON OCCURRENCE (470 m)
SUMMERVILLE OCCURRENCE
FALMOUTH OCCURRENCE (170 m)
SHUBENACADIE-STEWIACKE DEPOSIT (100-500 m)
HANTS-COLCHESTER AREA
MAHONE BAY AREA (no salt known or indicated)
KINGS
HANTS
HALIFAX
LUNENBURG
ATLANTIC
Liscomb
Game
Sanctuary
HALIFAX
DARTMOUTH
St Margaret
Mahone
Bay
64°00′
63°30′
63°00′
62°30′
45°00′
44°30′
Lower Carboniferous Windsor Group
Structural areas
TYPE B?-C (D?) (local diapirs)
Major Thrust Faulting
TYPE A (salt rare)
TYPE B?-C (D?)
TYPE D (major diapirs)
TYPE B-C
TYPE A
Gravity Slide Areas
NORTHUMBERLAND STRAIT
ATLANTIC OCEAN

Distribution of salt deposit structural types in Nova Scotia

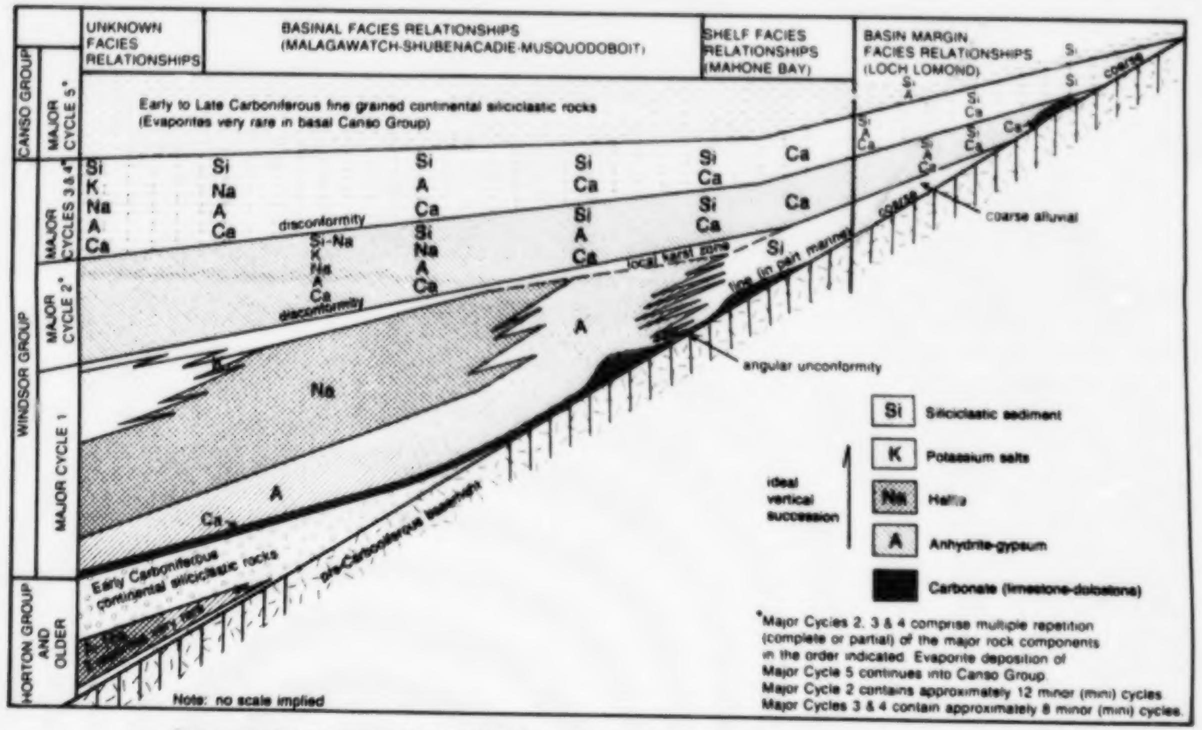
Nova Scotia Department of Mines and Energy

Canada Regional Economic Expansion / Expansion Economique Régionale


GUYSBOROUGH
HALIFAX
ATLANTIC OCEAN
SHUBENACADIE-STEWIACKE DEPOSIT
(100-500 m)
HANTS-COLCHESTER AREA
Liscomb Game Sanctuary
DCg
€O
€CH
LC
63°30′
63°00′
62°30′
62°00′
61°30′
61°00′

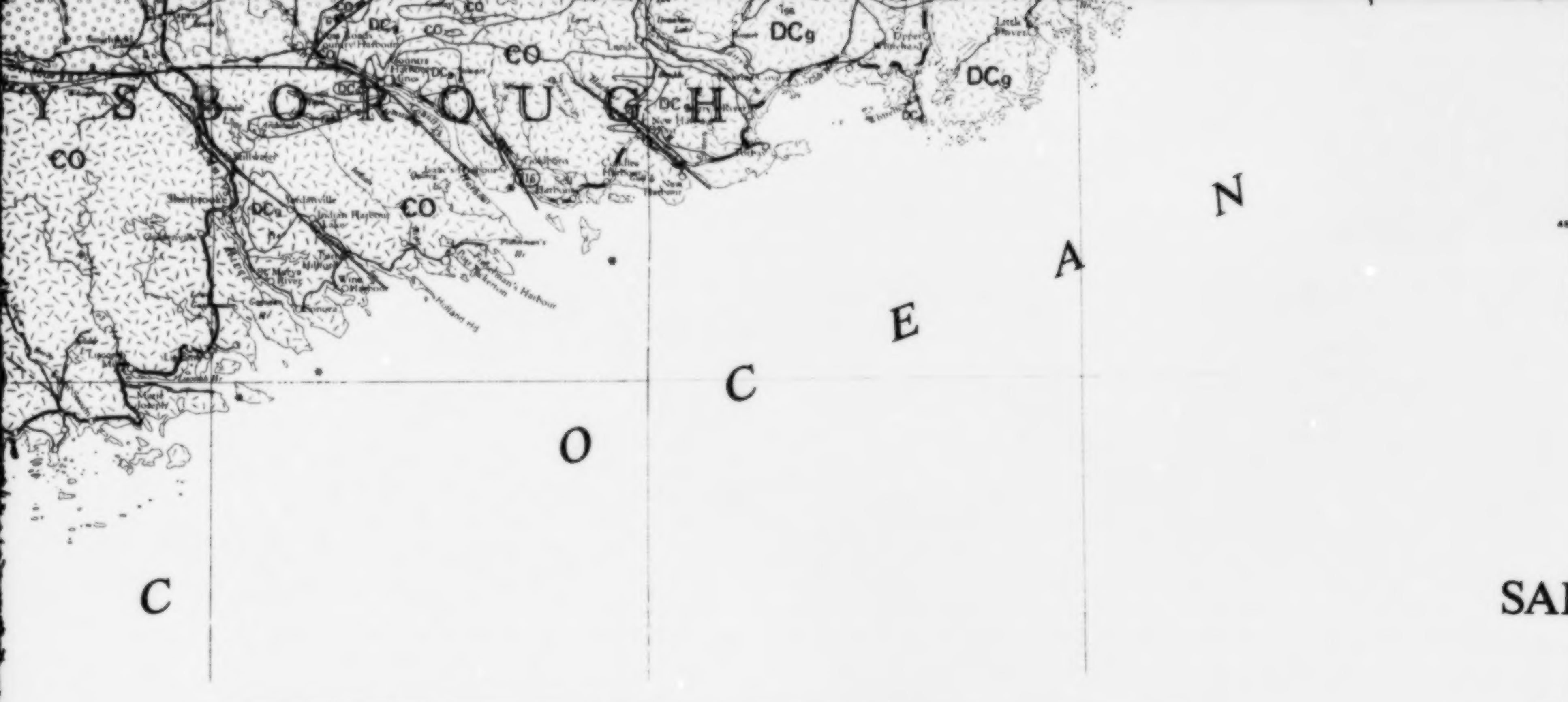

Lower Carboniferous Windsor Group
Structural areas
NORTHUMBERLAND
STRAIT
TYPE B?-C (D?)
(local diapirs)
Major
Thrust
Faulting
TYPE A
(salt rare)
TYPE D
(major diapirs)
TYPE B-C
TYPE B?-C (D?)
TYPE A
Gravity
Slide
Areas
ATLANTIC
OCEAN

Distribution of salt deposit structural types in Nova Scotia

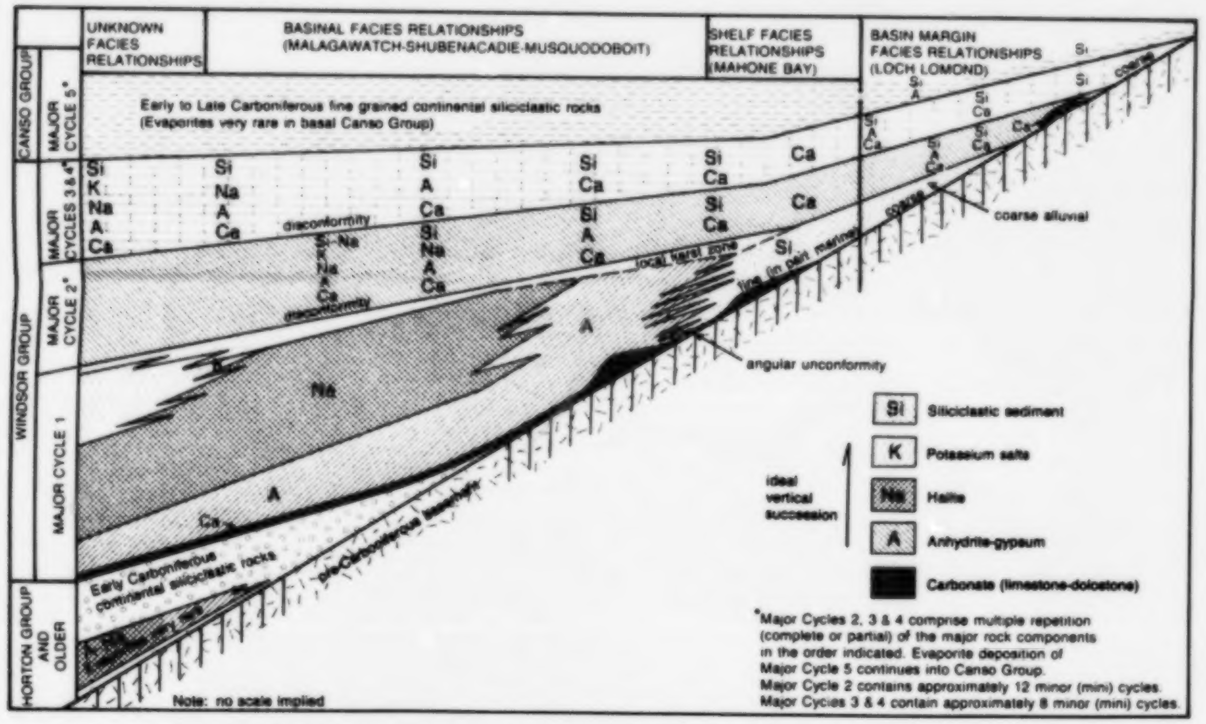

UNKNOWN FACIES RELATIONSHIPS
BASINAL FACIES RELATIONSHIPS (MALAGAWATCH-SHUBENACADIE-MUSQUODOBOIT)
SHELF FACIES RELATIONSHIPS (MAHONE BAY)
BASIN MARGIN FACIES RELATIONSHIPS (LOCH LOMOND)
CANSO GROUP
MAJOR CYCLE 5*
WINDSOR GROUP
MAJOR CYCLES 3 & 4*
MAJOR CYCLE 2*
MAJOR CYCLE 1
HORTON GROUP AND OLDER
Early to Late Carboniferous fine grained continental siliciclastic rocks
(Evaporites very rare in basal Canso Group)
disconformity
local karst zone
fine (in part marine)
coarse
coarse alluvial
angular unconformity
Early Carboniferous continental siliciclastic rocks
pre-Carboniferous basement
Si
K
Na
A
Ca
Si Siliciclastic sediment
K Potassium salts
Na Halite
A Anhydrite-gypsum
Carbonate (limestone-dolostone)
ideal vertical succession
Note: no scale implied

*Major Cycles 2, 3 & 4 comprise multiple repetition (complete or partial) of the major rock components in the order indicated. Evaporite deposition of Major Cycle 5 continues into Canso Group.
Major Cycle 2 contains approximately 12 minor (mini) cycles.
Major Cycles 3 & 4 contain approximately 8 minor (mini) cycles.

Schematic diagram of typical Windsor Group facies relationships recognized within Nova Scotia


YSBOROUGH
DCg
CO
DC
Sherbrooke
O C E A N
C
62°00′
61°30′
61°00′
60°30′
60°00′
45°00′
44°30′

GULF OF ST. LAWRENCE
ISLAND OF NEWFOUNDLAND
St. John's
MAP AREA
NEW BRUNSWICK
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
U.S.A.
Fredericton
Charlottetown
Sydney
BAY OF FUNDY
Halifax
ATLANTIC
OCEAN
SABLE ISLAND
45°
65°
60°
55°


UNKNOWN FACIES RELATIONSHIPS
BASINAL FACIES RELATIONSHIPS (MALAGAWATCH-SHUBENACADIE-MUSQUODOBOIT)
SHELF FACIES RELATIONSHIPS (MAHONE BAY)
BASIN MARGIN FACIES RELATIONSHIPS (LOCH LOMOND)
CANSO GROUP
MAJOR CYCLE 5*
Early to Late Carboniferous fine grained continental siliciclastic rocks (Evaporites very rare in basal Canso Group)
WINDSOR GROUP
MAJOR CYCLES 3 & 4*
MAJOR CYCLE 2*
MAJOR CYCLE 1
HORTON GROUP AND OLDER
Si K Na A Ca
Si Na A Ca
Si A Ca
Si Ca
Si Ca
Ca
disconformity
Si-Na K Na A Ca
disconformity
Si Na A Ca
Si A Ca
Si Ca
Ca
local karst zone
Si
fine (in part marine)
coarse
coarse alluvial
coarse
angular unconformity
Na
A
Ca
Early Carboniferous continental siliciclastic rocks
pre-Carboniferous basement
Note: no scale implied
Si Siliciclastic sediment
K Potassium salts
Na Halite
A Anhydrite-gypsum
Carbonate (limestone-dolostone)
ideal vertical succession
*Major Cycles 2, 3 & 4 comprise multiple repetition (complete or partial) of the major rock components in the order indicated. Evaporite deposition of Major Cycle 5 continues into Canso Group.
Major Cycle 2 contains approximately 12 minor (mini) cycles.
Major Cycles 3 & 4 contain approximately 8 minor (mini) cycles.

Schematic diagram of typical Windsor Group facies relationships recognized within Nova Scotia

SALT AND POTASH RESOURCES

OF

NOVA SCOTIA

MAP 83-3

COMPILED BY R. C. BOEHNER

1984

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY

HONOURABLE JOEL R. MATHESON, Q.C. **MINISTER**	**JOHN J. LAFFIN, P. ENG.** **DEPUTY MINISTER**

SCALE 1:500,000 or 7.89 miles to 1 inch

Miles 10 0 10 20 30 Miles

Kilometres 10 0 10 20 30 40 Kilometres

Planimetric base is from Canadian Department of Energy, Mines and Resources, Surveys and Mapping Branch
Map MCR 37, Scale 1:500,000
Geological base is modified from the Geological Map of Nova Scotia (Keppie, 1979)
Transverse Mercator Projection
Jointly funded by the Nova Scotia Department of Mines and Energy and the Canada Department of Regional Economic Expansion
Cartography by Nova Scotia Department of Mines and Energy and by Maritime Resource Management Services

To accompany Nova Scotia Department of Mines and Energy, Bulletin No. 5 (Figure 1-10)